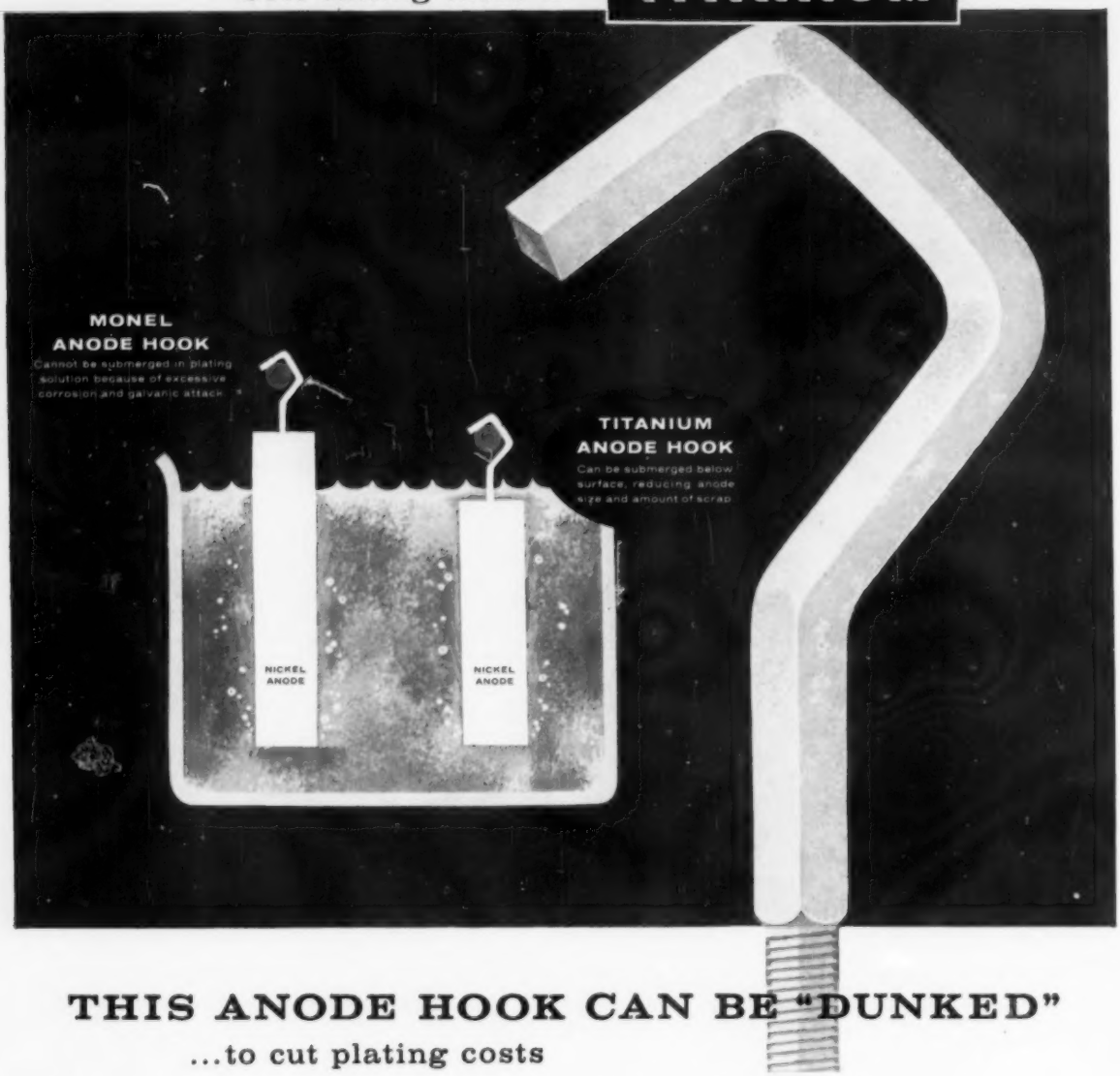

METAL MADNESS

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Titanium hooks, anode baskets and heating coils are now cutting costs in a number of large-scale plating applications... examples of how Mallory-Sharon's development work in titanium is paying off for industry.

Write for Technical Data Sheet and application information on titanium anode hooks, or any other high-corrosion problems you may have. Please address: Commercial Market Development, Dept. A, Mallory-Sharon Metals Corp., Niles, Ohio.

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Metal Progress

February 1959 . . . Volume 75, No. 2



COVER: "Sparks From a Grinding Wheel", by NANCY BUKOVNIK; first prize winner in 1958 *Metal Progress* Cover Competition at Cleveland Institute of Art.

Western Metal Congress and Exposition

Consolidated Program 97

Technical Programs of Cooperating Societies 98

Sessions planned for the week of March 16 in Los Angeles by the American Society for Metals (including the William Park Woodside Panel Conference), the American Institute of Mining, Metallurgical and Petroleum Engineers, the American Welding Society and the Society for Nondestructive Testing.

Progress in Heating

Buying Industrial Heating Equipment, by C. F. Olmstead 65

Improvements in Induction Heating, by W. E. Benninghoff 66

Vacuum as a Furnace Atmosphere, by L. W. Johnson 71

Austempering and Martempering Practices, by A. F. Holden 74

Advances in industrial heating are reported in these four articles prepared from papers presented at the Industrial Heating Equipment Assoc. Symposium at the National Metal Congress, Cleveland. C. F. Olmstead stresses the need for full cooperation between buyer and seller which enables selection of the most suitable equipment for the job. Many automatic handling devices are included with induction heating units today, reports W. E. Benninghoff. Vacuum is now considered a standard "atmosphere", particularly for heat treating the highly reactive metals, according to L. W. Johnson. Austempering and martempering equipment – A. F. Holden discusses this – continues to improve. (J-general, 1-5*)

Engineering Articles

An Economic Appraisal of Stainless Steel and Zirconium in Nuclear Power Reactors, by Manson Benedict 76

Zirconium (as Zircaloy) instead of stainless steel as structural material, fuel cladding or fuel diluent in nuclear reactors makes savings possible through use of uranium of lower enrichment or reduction in the critical mass. Five power-producing thermal reactors were chosen to span the entire range of fuel enrichment. (W11p, 17-57; SS, Zr-b)

Licking the Problem of Stress-Corrosion Cracking, by John F. Klement, Robert E. Maersch and Patrick A. Tully 82

High-pressure steam, either pure or containing acid or salt vapors, quickly causes intergranular cracks in aluminum bronze pressure vessels. Apparently grain boundaries are slightly enriched in aluminum, and this is oxidized preferentially. The trouble is permanently avoided by addition of a fractional percent of tin. (R1d, R4d, 2-60; Cu-s, *Al*, *Sn*)

Vacuum Metallurgy in Europe, by A. M. Aksoy 87

Melting techniques, particularly vacuum degassing, have progressed rapidly since World War II. Though vacuum induction and arc melting have not developed as they have here, their potential is beginning to interest fabricators who need better and more dependable alloys. (C25, D8m, J-general, 1-73)

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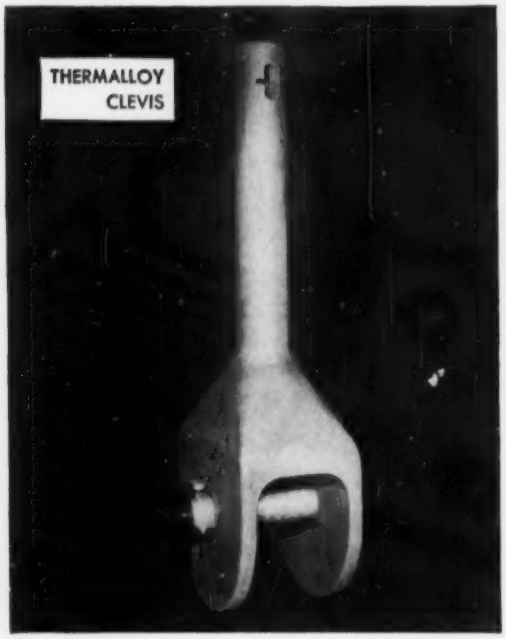
Thermalloy clevis design simplifies the heat treatment of large forgings

A manufacturer of large forgings uses the Thermalloy* clevis to heat-treat forgings weighing 30,000 to 74,000 pounds. The heat-treatment cycles range up to 300 hours with a maximum temperature of 1850°F.

Engineers from Electro-Alloys and the manufacturer working together developed the clevis for this heat-treating operation. The original lifting rig weighed four times as much as the Thermalloy clevis that replaces it. This reduces the total weight the crane must support in the furnace. The Thermalloy clevis simplifies lifting the forging by eliminating the wedging adjustment. Further, it eases the problem of positioning the forging in the furnace.

For advanced heat-resistant alloy-casting design service, contact your local Electro-Alloys representative or write: Electro-Alloys Division, American Brake Shoe Company, 90312, Taylor St., Elyria, Ohio.

*Reg. U. S. Pat. Off.





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ELECTRO-ALLOYS DIVISION • Elyria, Ohio

Metal Progress

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High-Strength Steel Can Be Cadmium Plated Without Embrittlement, by D. J. Cash and W. Scheuerman 90

Cadmium is plated from a cyanide bath at 70 amp. per sq. ft. to give a porous plate which permits hydrogen to diffuse out of the surface in subsequent bake. A sustained load specimen, of much higher sensitivity, replaces the unnotched tensile test piece. (L17c, Q26s; ST, SGB-a, Cd)

Three New Low-Hydrogen Iron-Powder Electrodes, by D. C. Smith and W. G. Rinehart 102

Three new electrodes have been developed for high-strength weldments which will respond to heat treatment, such as are used in aircraft. Tests show that the weld metal matches hardness and tensile strength of the base at tempering temperatures between 450 and 1250° F. (W29h, Q-general; AY, SGB-a)

You Can Do More With CO_2 Welding, Staff Report 110

Improvements in carbon dioxide Mig welding are opening up new horizons for this low-cost high-speed process. More efficient techniques are overcoming previous limitations and permit a wider range of applications in steel fabrication (K1d, 1-52)

Biographical Appreciation

Clarence H. Lorig 94

President, American Society for Metals 1958-59; Technical Director, Battelle Memorial Institute; First Recipient of the Eisenman Medal of the Philadelphia Chapter.

Brazing Processes, Equipment and Procedures, Reviewed by William M. Lehrer 101

"Brazing Manual", prepared by the Brazing Committee of the American Welding Society, is particularly useful to anyone faced with modern joining problems who is relatively unfamiliar with brazing. Deals with general procedures as well as specific instructions for joining individual metals or groups of metals.

Short Runs

A Luminous Wall Furnace 108

The ability to heat to red heat and above in seconds cuts fuel costs appreciably.

Plasma Arc Torch 108

Process can be used not only to apply coatings of refractory metals but also to build up shapes by depositing successive coatings on a spinning mandrel.

Data Sheet

Hardenability Bands for Steels 4720-H to 50B60-H 96-B

Metals Engineering Digest

Better Aircraft Engines 124

Such are the incentives for the aircraft engineer to develop new materials or processes that the aircraft engine has become a metallurgical proving ground, according to W. Paul Eddy in the Annual Woodside Lecture before the Detroit Chapter.

Stainless Steel in Automobiles 132

With 100,000 tons of stainless consumed by the automotive industry in 1956 and 1957, a session on present and future applications at the December 1958 meeting of the A.I.M.E. Electric Furnace Conference highlighted some important problems.

Modern Machining Methods 138

Seven practical papers presented at the William Park Woodside Conference of the A.S.M. during the Metal Show last fall are reviewed by F. W. Boulger.

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Press Breaks...



TWO WRONGS don't make a right. Though usually true, Clichés Union, the Parisian engravers who make our cover plates with unique skill, have apparently disproven this adage.

It seems that the original photographic negative for the December 1958 cover – miniature at right – contained tones which were lost in the print displayed at the 1957 Metallographic Exhibit. We thought the print striking enough to serve as a future cover. So, obtaining permission from the exhibitors, we shipped it to France for the color plates. Our engravers somehow managed to alter their generally accurate procedures just enough to recover the lost tones – or so J. E. Rainey (head, metallurgical dept., Detroit Testing Laboratory, Inc.), donor of the print, reports. In his letter he says, "We commend you on the splendid reproduction made by your craftsmen. The color shown on this reproduction more closely simulates the actual true color shown in the transparency." Crazy things like this happen in publishing; for once, one of them worked in our favor!

While we thought the photograph had a pleasant Christmas motif, we wonder how many noticed the shadowy crucifix? Turn the print 45° counterclockwise.

The Metallographic Exhibit is an annual project for *Metal Progress* editors. Since each picture represents outstanding metallographic technique, much care should go into preparing the exhibit itself. Here's what happens: Entries, wrapped in everything from butcher paper to steel-strapped cases, flow into Marjorie Hyslop's office from all over the world. They are unwrapped, numbered and recorded. A few days before the show opens, the staff troops down to the exhibit hall, and struggles with pegboards, stands, tables, clips, signs, tacks, and broken fingernails. When the exhibit is finally ready, three judges, chosen experts, decide the winner and then go to the best lunch we can buy for them. Since the photographs are known only by number until judging is over, each picture is finally tagged with name of the metallographer responsible for it.

Incidentally, those who missed the Cleveland show will be able to see the prize and honorable mentions at the 11th Western Metal Congress and Exposition in Los Angeles, March 16 to 20, 1959. As a glance at p. 97 will show, technical sessions at the Hotel Ambassador cover a large variety of important subjects. If you're going, start planning now; time is getting short.

The staff report on CO_2 welding in this issue (p. 110) merits your careful attention since Dave Ritchie, one of the assistant editors, worked on it for several weeks. Beginning his travels at Buffalo, N.Y. (Westinghouse Electric Corp.), he progressed to Troy, Ohio (Hobart Bros. Co.), and Milwaukee, Wis. (A. O. Smith Corp.). The Milwaukee journey was enlivened by a snowstorm which necessitated an airplane landing in Chicago; the rest of the trip was made by "road and dog sled" according to Dave. (Fortunately for him, he was raised in St. John, New Brunswick!) Finishing in Chicago at National Cylinder Gas and Liquid Carbonic, he hurried back to Cleveland, deposited about 10 lb. of unorganized data, and zipped off to New York for a visit to Air Reduction Sales Co. Following a tour of their laboratories in Murray Hill, N.J., he dropped in to inspect the operations of Linde Co.'s development group. The use which fabricators are making of this process also came under his appraising eye. Dana Corp. (Reading, Pa.), Borg-Warner Corp. (York, Pa.), and Fisher Body Div., General Motors Corp. (Detroit) all provided helpful information for the article. Dave came back just before Christmas, staggering under a mountain of material.

Naturally, all of this information required time for organization. *We* think Dave did a nice job, one well worth your attention; let us know what *you* think.

THE EDITORS

BRUSH
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BULLETIN

application
and
fabrication
news

DESIGNING WITH BERYLLIUM IS SIMPLIFIED BY BRUSH GUARANTEED PROPERTIES.

Aircraft and missile manufacturers now purchase BRUSH QMV beryllium block and sheet with fixed and guaranteed minimum physical properties. These guaranteed property values are being used as design allowables, confirming beryllium metal as a practical engineering material.

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Beryllium's combination of high specific heat, high strength and rigidity are being utilized in the design of a number of missile and space-craft components. Atmosphere re-entry requires the absorption of large heat loads at high temperatures. Beryllium's ability to withstand re-entry conditions has been confirmed in static and flight tests. Control surfaces and leading edges are being designed utilizing the light weight and elevated temperature rigidity of beryllium.

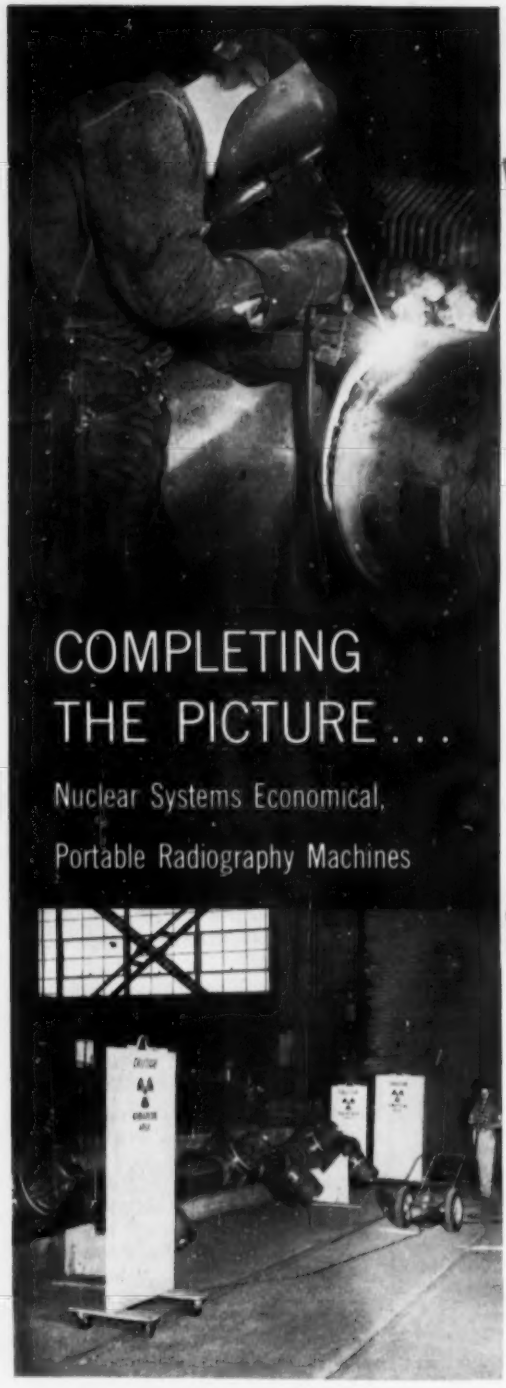
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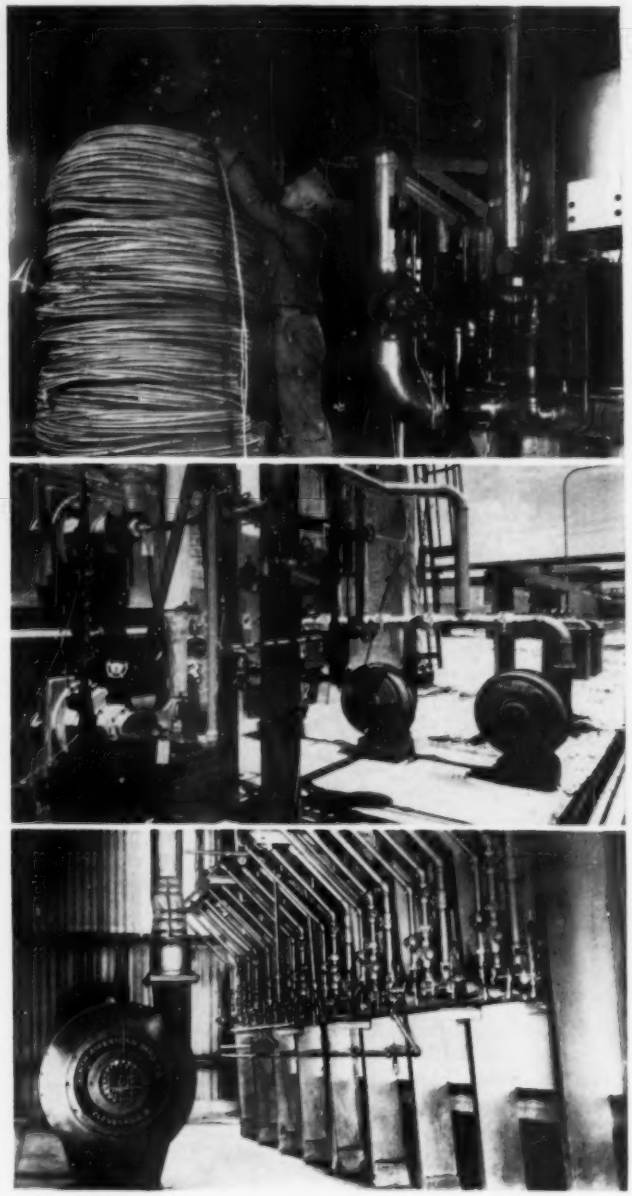
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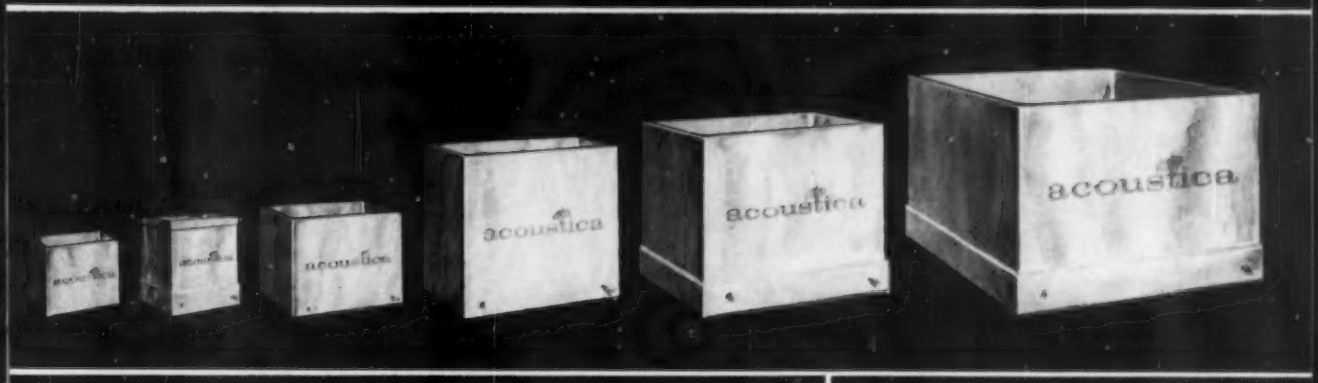
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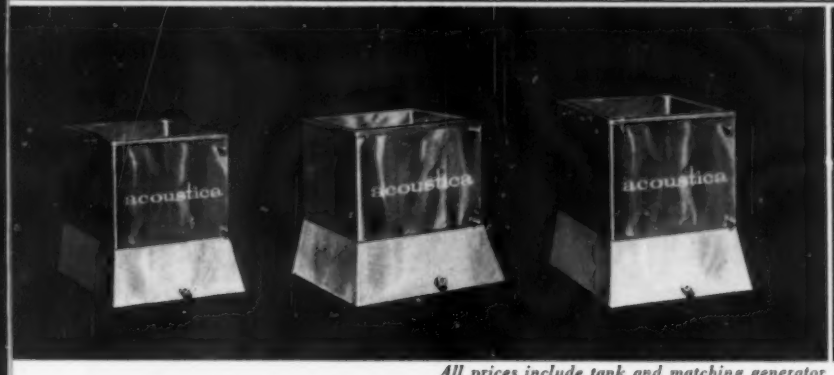


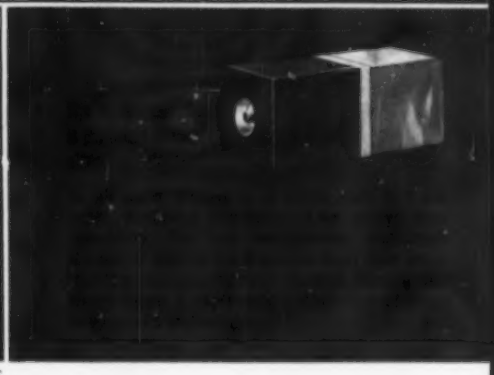
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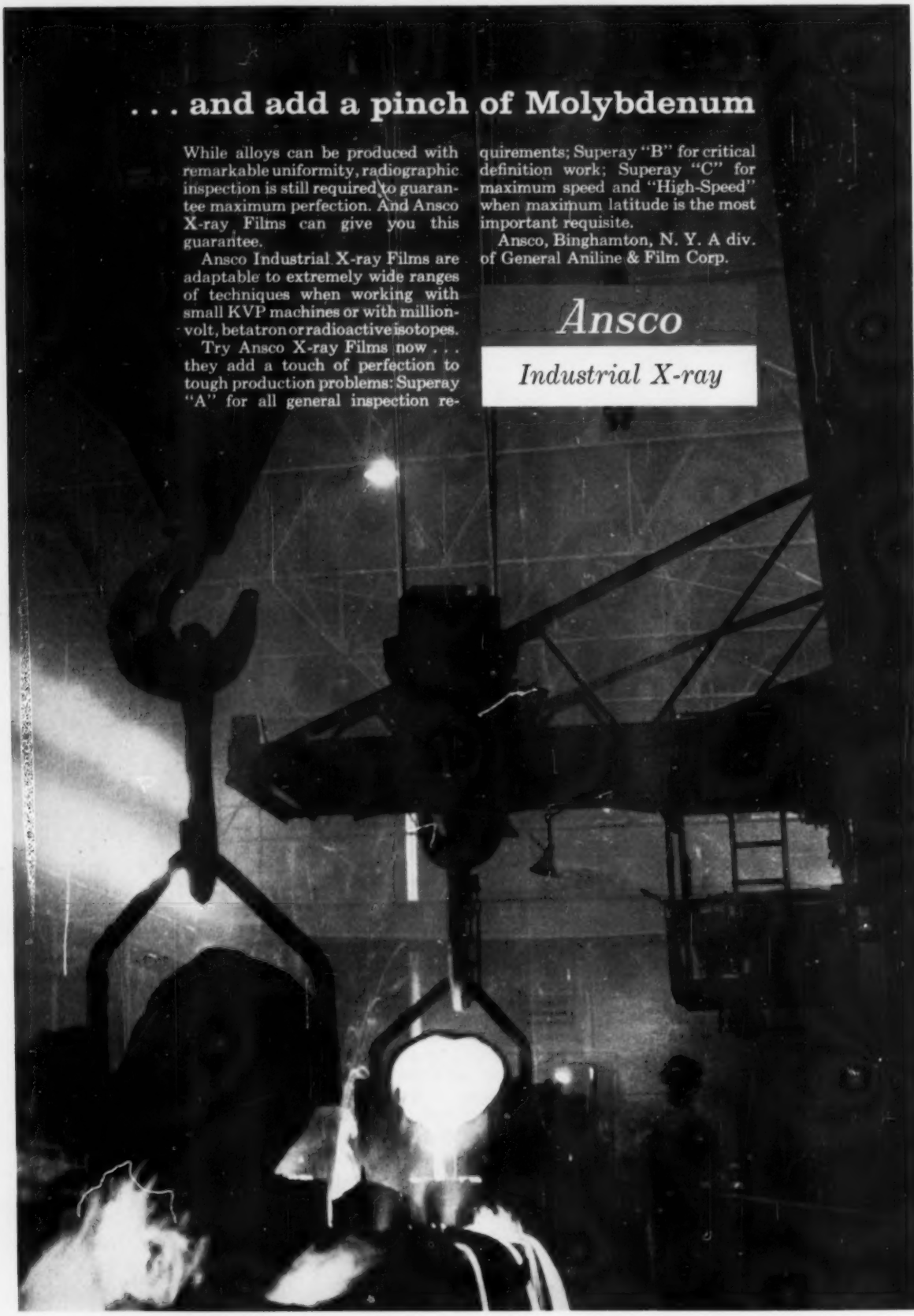
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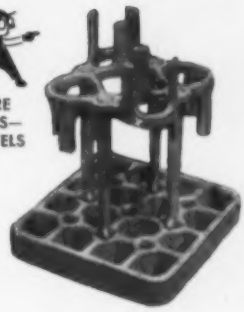
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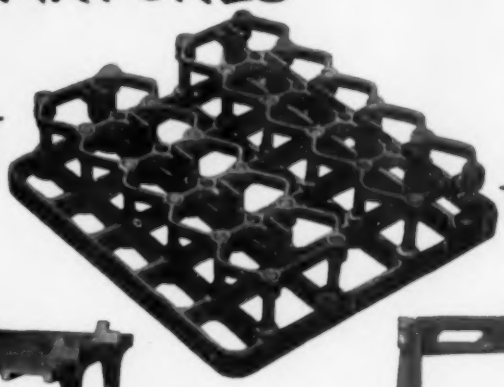
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Lamson & Sessions Co.: Operator checks loading of furnace used to harden bolts made of 1038, 1335 and 4140 steel.

Reproducibility of hardening temperatures a problem?

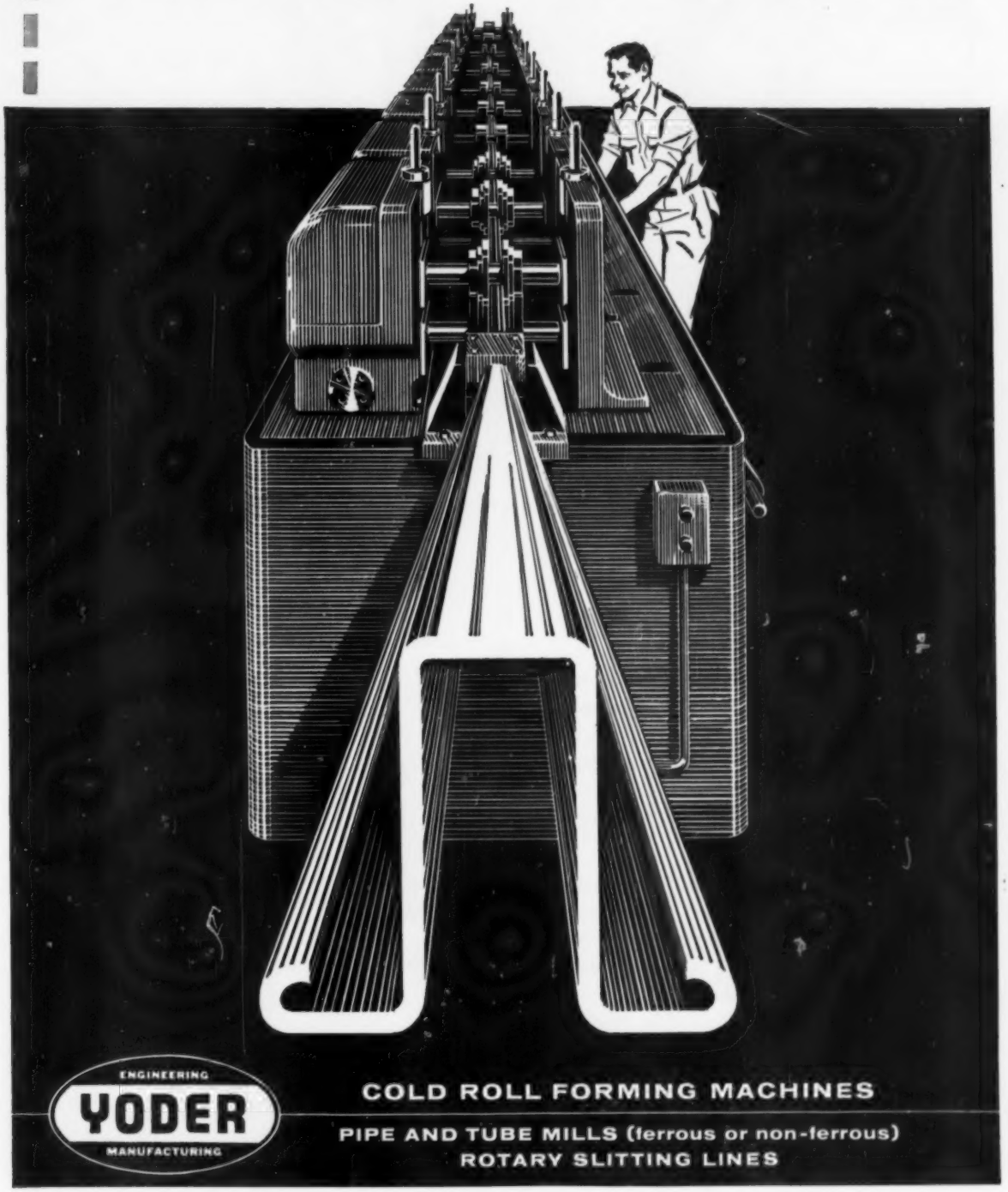
Not at Lamson & Sessions Co.'s Chicago plant, where Speedomax® H controllers are helping to assure reproducibility of hardening specs for nuts and bolts. With competition keen, dependability and reproducibility of processing equipment is a "must". Since installation nearly two years ago, Speedomax H has been controlling temperature of hardening and draw furnaces 5 days/wk, 24 hrs/day. Weekends, furnaces idle at control temperature. Maintenance has been negligible . . . temperature always within specs. Rugged, compact and completely reliable, Speedomax H is providing the same dependable control on numerous heat treat operations . . . is helping produce both process economies and a quality product. *Whatever your heat treating process, it'll pay you to investigate Speedomax H!* For details, contact your nearest L&N office or write 4927 Stenton Ave., Phila. 44, Pa.



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Roll Forming Equipment—Product dependability—integrity of manufacture—engineering for specific production needs have all contributed to establish Yoder equipment as the industry standard of excellence. Since 1909 Yoder-built machinery, including Pipe and Tube Mills, Roll Forming Equipment and Rotary Slitters, have earned world-wide customer satisfaction and recognition. Profit from Yoder's years of engineering and service experience. Send today for the illustrated Yoder Roll Forming Equipment Book.

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PIPE AND TUBE MILLS (ferrous or non-ferrous)
ROTARY SLITTING LINES

"...our instruments like Honeywell accessories, too!"



INSTRUMENTS "know" the difference. They do their best with accessories designed for them by an instrument manufacturer.

It takes an instrument man to make the perfect match between instruments and accessories. Your Honeywell instrument sales engineer knows your process and its controls, and which accessories are best suited to both. He can choose from a broad line of charts, inks, thermocouple wire, wells and protecting tubes.

Additional advantages gained from buying Honeywell accessories are convenience, economy and single-source purchasing. No shopping around. No need to "mix breeds." And you can be sure that whatever you buy will be right for the job. Your Honeywell instrument sales engineer will see to that. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Here's one product from the complete Honeywell accessories line:

CAST IRON T/C PROTECTING TUBES



This is one of the protecting tubes recommended for use with molten aluminum or die casting applications. It can be used at maximum temperatures of 1300° F. in oxidizing atmospheres, and 1600° F. in reducing atmospheres. Available in standard lengths of 12, 18, 24, 30 and 36 inches.

All Honeywell cast iron protecting tubes are Beta-gage checked for uniform concentricity . . . assuring maximum life.

Honeywell

First in Control

Vacuum Cleaner Manufacturer Specifies

OSTUCO *Fabricated Welded Tubing*



Bending vacuum cleaner wand. A variety of fabricating operations also is performed on Ohio Special Quality Seamless Tubing.

"Value analysis showed it would be more economical to buy than produce fabricated welded tubing parts for our new cleaner. What's more, we could avoid additional capital investment in equipment.

"So we added Ohio Seamless to our production line. They have the equipment and facilities to meet our design requirements and to hold to our stepped-up schedules. And we don't pay shipping costs on scrap — just on finished parts . . ."

Let Ohio Seamless translate your designs into finished parts . . . conserve your capital . . . cut your production and shipping costs. Contact your Ohio Seamless representative, listed in the Yellow Pages, or the mill at *Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America.*

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review of metal literature

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Each "Review" is your reference to all published information on metals during the respective year. Each carries approximately 800 pages of bibliography and reference covering the output of all printed material throughout the free world. A complete set contains almost 100,000 annotations!

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3	May 1947 ☐	9	July 1953 ☐
4	Aug. 1948 ☐	10	July 1954 ☐
5	July 1949 ☐	11	June 1955 ☐
6	July 1950 ☐	12	June 1956 ☐
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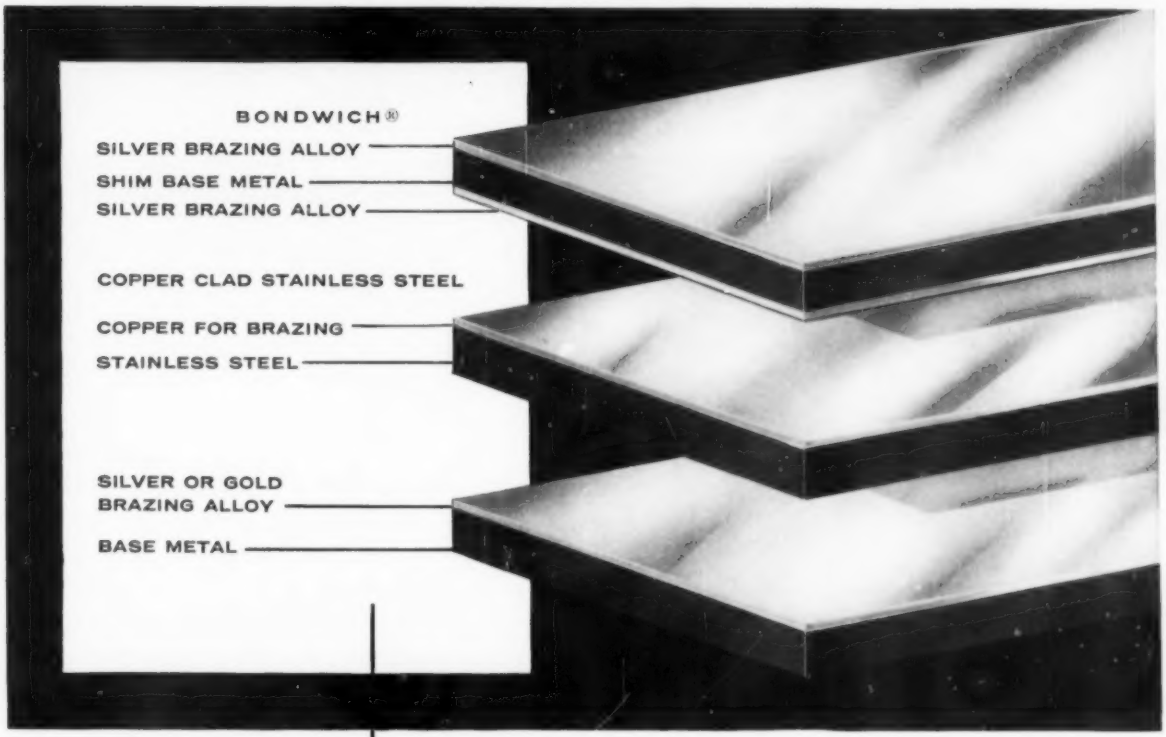
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AMERICAN SOCIETY FOR METALS
Technical & Engineering Books
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TWO METALS ARE OFTEN BETTER THAN ONE ...and GENERAL PLATE CLAD METALS for brazing are a case in point–



General Plate can supply you with many clad metals made specially for brazing . . . copper clad stainless steel, silver brazing alloys, clad stainless and non-ferrous metals. Also, soft solders clad on nickel and copper. All are made by permanently bonding a solid layer of brazing metal on one or both sides of the parent metal — which can be either base, precious or clad metal.

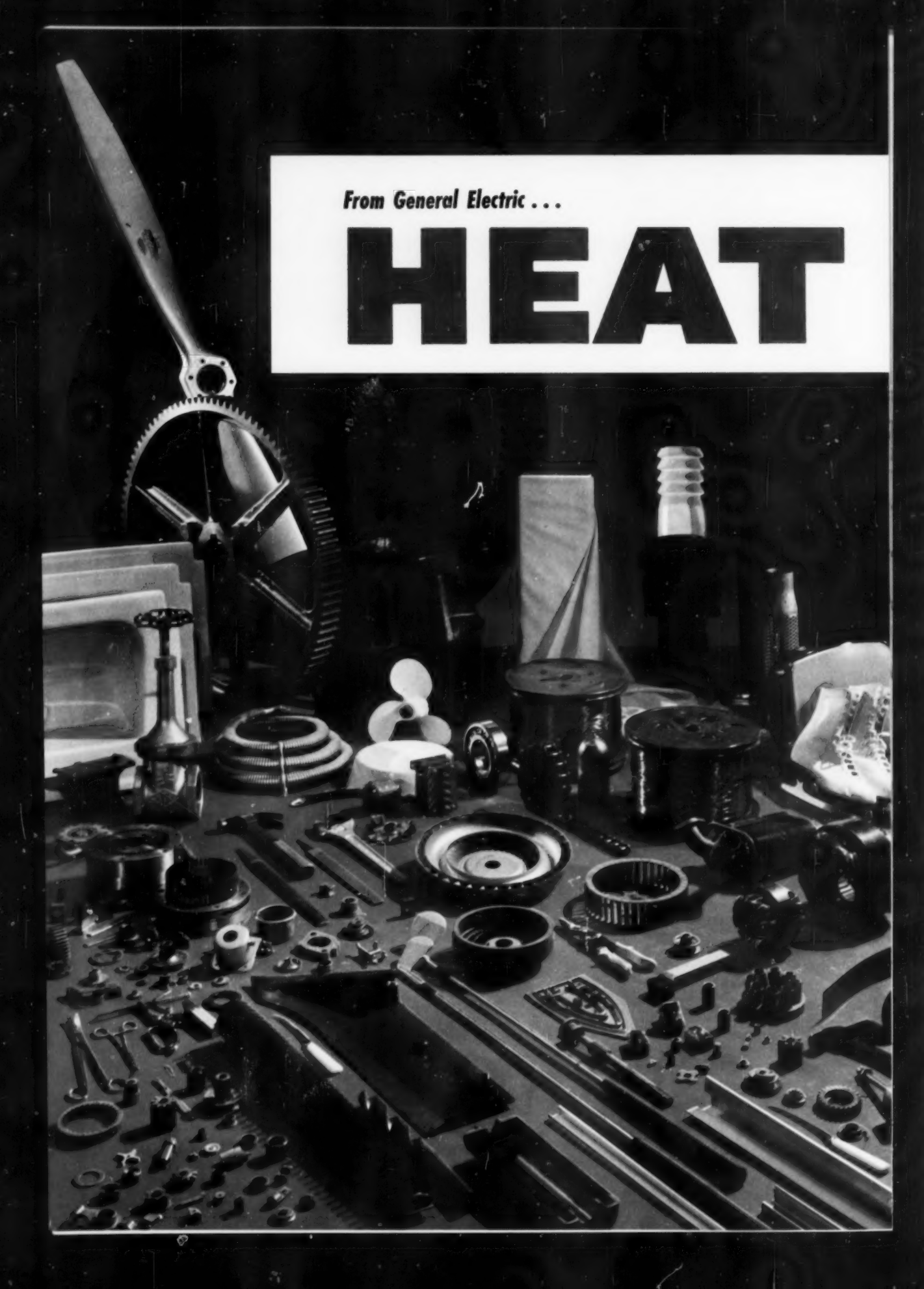
Here's how you benefit by using these metals —

- 100% coverage because brazing metal is completely wetted on parent metal
- Low assembly costs — brazing alloy is already preplaced on metals being joined
- No excess of brazing metal — good appearing joints
- Stronger joints — usually require less thickness of brazing alloy than when separate brazing foil used
- Brazing metals available to suit all types of heating atmospheres

General Plate can furnish you with a wide selection of metals clad with brazing alloys to fill your requirements. Write for Bulletins.

You can profit by using General Plate clad metals.

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From General Electric . . .
HEAT

CUSTOMER SAVES $45,000 IN ONE YEAR

New General Electric furnace development offers similar savings for other bright stainless steel brazing and heat treatment operations.

General Electric design and engineering skill have produced another significant improvement in the construction of heat processing equipment. Engineering development on the application of high purity refractories eliminated the need for metal muffles for this bright stainless annealing and brazing operation which requires high temperature, low dew point heat treatment.

As a result, maintenance and downtime expense for replacing the muffles was eliminated; atmosphere leakage was greatly reduced, and consequently, the customer saved enough to pay the initial cost of the equipment in one year!

This new development, with its significant savings, is equally applicable for other brazing and heat treatment equipment requiring high temperatures and a low dew point. For instance, this design can be adapted to roller hearth, bell, pusher and other furnace types.

Call your G-E Heating Specialist now. He will be pleased to figure your potential savings with new heat processing equipment. The items in the picture at left may offer you ideas on products you process which would be adaptable to General Electric gas-fired or electric furnaces. Contact your nearest General Electric Apparatus Sales Office or write Section 721-22, General Electric Company, Schenectady 5, New York.

The items shown at left are typical of the many products which have benefited from General Electric heat treatment developments—and cost savings often result. For example: substantial savings resulted when high-purity brick was used in this mesh-belt furnace. This technique eliminated the need for costly furnace muffles which require frequent replacement. This is a major technological advance for the furnace industry with today's trend toward higher temperature operation and the need for atmospheres with very high purity. Similar savings can be made for other difficult to treat components which require bright brazing or heat treatment.



Progress Is Our Most Important Product

GENERAL ELECTRIC

Memo on Metals

New Age-hardenable Titanium Alloys Offer Up to 220,000 psi Tensile Strength and Easier Formability for 600 to 1,000 F Applications

Three new age-hardenable titanium alloys may prove to be the solution to many of the strength-weight and temperature problems encountered in designing advanced aircraft and missiles. They may also prove extremely economical for such applications.

All three offer much higher strengths than other titanium alloys – and have the light weight and corrosion resistance typical of titanium alloys. Furthermore, they are readily FORMAGEABLE* – capable of being formed in the solution-treated or "soft" condition and then strengthened by simple thermal aging techniques. Each is now in pilot production and available in limited quantities of mill products.

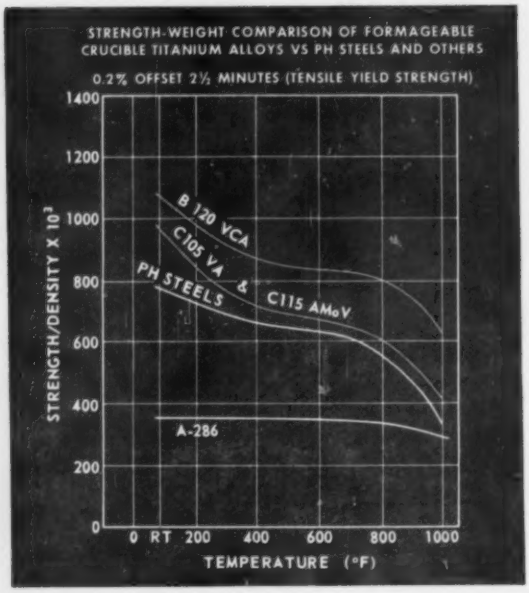
First Age-hardenable All-beta Ti Alloy

Crucible B-120VCA is the first useful titanium alloy with an all-beta (high temperature) structure. It has both the highest strength and best formability of any titanium-base alloy.

This alloy's composition (13%V-11%Cr-3%Al) enables its structure to stay all-beta during forming and/or during slow cooling, and to age to high strength levels at temperatures where distortion is not a problem.

B-120VCA has a unique combination of properties. Room temperature strengths of 200,000 to 250,000 psi have been obtained. On a strength-weight basis this is the highest strength of any available structural material. In short-time elevated temperature tensile tests (1-2 minutes), it offers a decided strength-weight advantage over alternate materials at temperatures up to at least 1,000 F. Under creep conditions, for very long periods of time, it enjoys a strength-weight advantage up to at least 600 F. Beyond this limit, the other Crucible FORMAGEABLE titanium alloys are recommended.

B-120VCA is ductile-weldable, cold-headable, and has great and deep hardenability. Because of this formability, it should prove suitable for applications such as aircraft skins, stiffeners and other primary structural shapes, and for missile pressure tanks, rocket motor cases and structural members. Preliminary tests indicate it may prove unequalled as a construction material for honeycomb assemblies. Because it is so easy to cold-head, it has a large potential in such items as rivets.



Alpha-beta Titanium-base Alloys

Crucible C-105VA is an alph-beta titanium-base material which also is FORMAGEABLE. Its 16% vanadium content stabilizes a sufficient amount of the beta phase for good age-hardenable response; the 2.5% Al content improves the alloy's elevated temperature properties.

C-105VA resolves two conflicting requirements for aircraft sheet material. It is soft, ductile and easily formed in the solution-quenched condition. Because the formed parts can be aged subsequently at moderate temperatures, parts made of C-105VA can possess high strengths at temperatures up to 800 F for long periods of time.

* *age-hardenable titanium alloys*
* *tool steels in production parts*
* *borated stainless steels*

This third alloy, C-115 AMoV (4%Al-3%Mo-1%V), also shows considerable promise for aircraft sheet applications. It is age-hardenable to higher strengths than C-105VA with only slight sacrifice in forming characteristics.

Considerable data on the properties and fabricating qualities of all three alloys have been assembled by Crucible's Titanium Division. For data sheets and additional information, send the coupon.

Tool Steels Replace Standard Alloys for Production Parts

As design and metallurgical engineers require materials with improved properties or greater uniformity, they are turning more to the use of tool steel for production parts. Here are three good examples:

1. Vanes in the hydraulic system that actuates the automatic steering mechanism on cars are made of Crucible REX® M-2 high speed steel. REX M-2 combines the abrasion resistance necessary for minimum wear with the impact resistance needed for long life and safety. The manufacturer experimented with numerous other steels, but high speed steel lasted longer than any other type tested.

2. Actuator bars for a nationally-known calculator are now being produced of Crucible KETOS® – a low-priced AISI Type O1 alloy tool steel – because the thin, close-tolerance contact edges withstood over 4-million high speed blows in a life test. No other steel has lasted more than 1-million cycles before chipping and failing.

3. Cylinder block for a fast acting, aircraft hydraulic pump made of Crucible Chrome tool steel. Pump operates at temperatures up to 500 F, pressures to 5,000 psi. Tool steel was selected over a standard AISI alloy because of its high degree of cleanliness, uniform response to heat treatment, and controlled hardenability. Furthermore, because tool steel practices are employed in making it, the steel more consistently meets the critical mechanical and physical properties required in this application.

For data sheets on these and all other Crucible tool steels – send the coupon.

High Boron Stainless Steels Made Possible by Vacuum Melting

Type 304 stainless steel with boron has proved to be an excellent material for nuclear equipment, because the boron readily absorbs neutrons. By increasing the boron content, valuable weight and thickness reductions can be made in reactor shielding and control rods.

Unfortunately, conventionally melted borated 304 becomes "hot short" – virtually impossible to work if the boron content exceeds 1%. Vacuum melting has provided the answer to this problem. Vacuum-melted 304 stainless is readily workable when the boron content goes up to 2% or even higher.

Vacuum melting the alloy also provides closer control of the composition, because only pure materials are used. So, undesirable elements such as cobalt – which becomes radioactive upon bombardment – can be kept to a minimum. In fact, vacuum-melted Type 304 stainless can be supplied with less than .001% cobalt.

For additional information on vacuum-melted steels – send the coupon.

CRUCIBLE STEEL COMPANY OF AMERICA
Dept. EB09, The Oliver Building
Mellon Square, Pittsburgh 22, Pa.

Gentlemen:
Please send me the following:

1. Data sheets on B-120VCA ☐ C-105VA ☐ C-115AMoV ☐
2. A copy of "Titanium Alloys for Aircraft and Spacecraft" by Finlay, Vordahl and Malone ☐
3. Data Book on Crucible tool steels ☐
4. Data sheets on vacuum-melted steels ☐

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Company_____
Street_____
City_____ Zone_____ State_____

CRUCIBLE STEEL COMPANY OF AMERICA

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■ A new method of high velocity convection heating nonferrous metals makes your present processing speeds extremely slow. For example, it will continuously anneal brass strip faster, with greater uniformity, than possible with conventional heating methods.

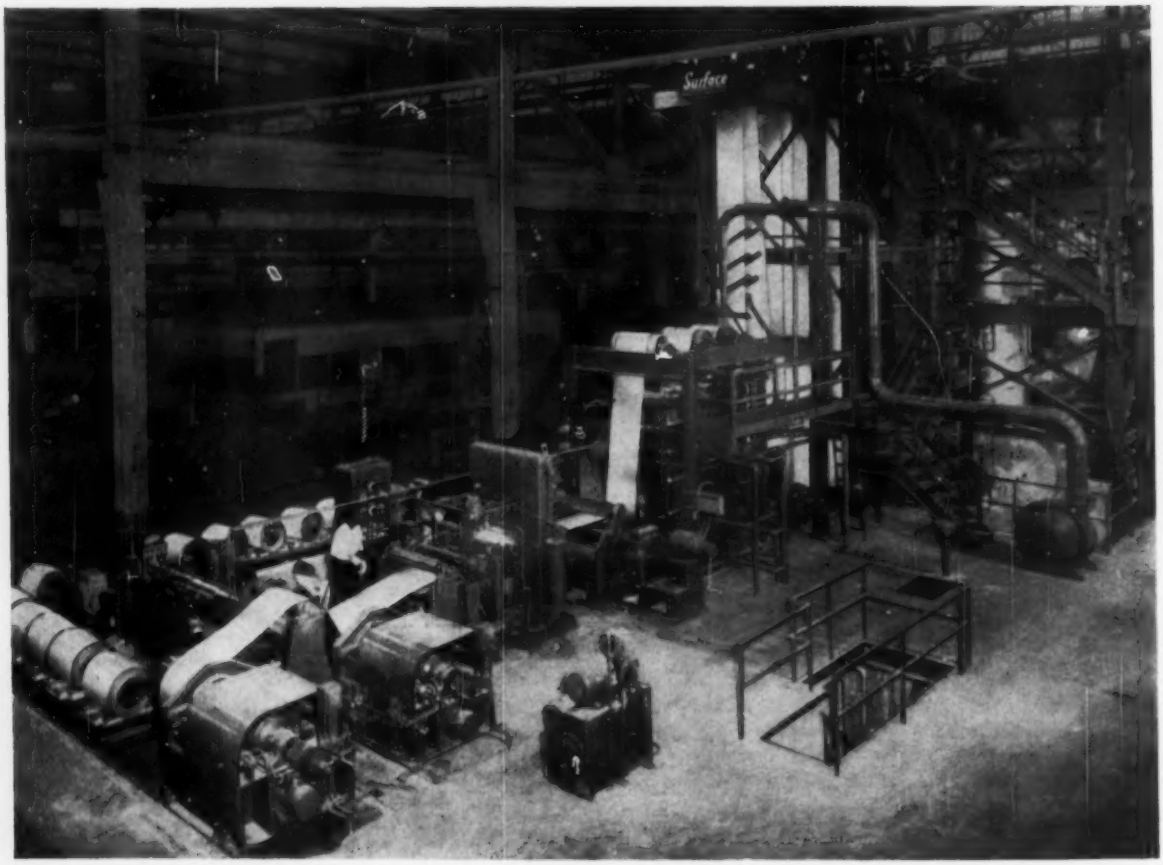
We have successfully applied this method to heating aluminum billets to forging temperatures with both startling and profitable results. It can be applied just as profitably to other types and forms of ferrous and nonferrous metals.

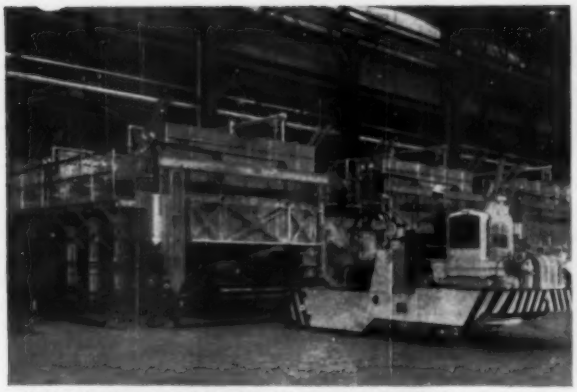
This is a result of a close association with the nonferrous industries over many years and many different applications, as shown here. We are confident that its great cost savings will make you want to talk immediately with one of our engineers.

Surface Combustion Corporation, 2377 Dorr Street, Toledo 1, Ohio. In Canada: Surface Industrial Furnaces, Ltd., Toronto, Ontario.

heat nonferrous metals faster...

Incredible speeds have been achieved in this new continuous brass strip heating installation by Surface.





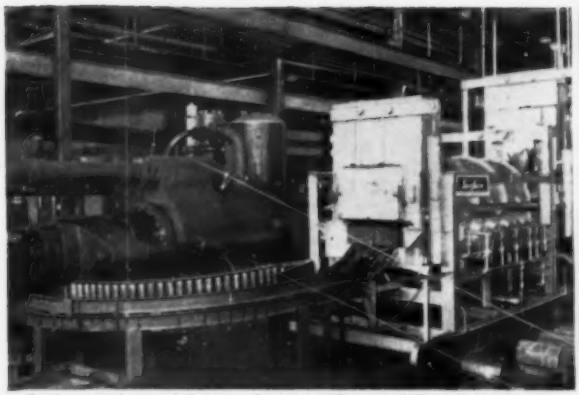
A big aluminum billet is removed from one of a battery of Surface furnaces which heat 7000 lbs/hr each for forging.



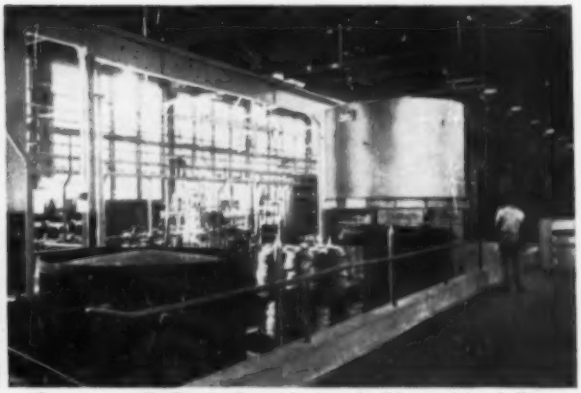
Thousands of 14S aluminum parts a day are solution heat treated and aged in this Surface continuous furnace line.

with new method by

wherever heat is used in industry



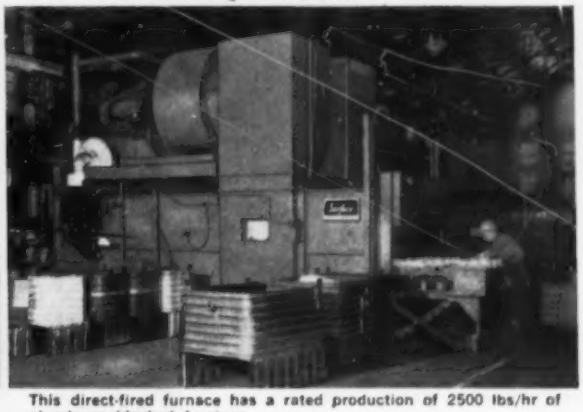
Surface high-speed furnace heats nonferrous billets for extrusion at a rate of 19,250 lbs/hr, with fine grain size.



"Super convection" cuts the cycle time in this precision bell annealer. Direct-fired heating's in the base.



Specified grain size of 0.040 mm is held easily in this Surface continuous bright annealer for copper tubing.

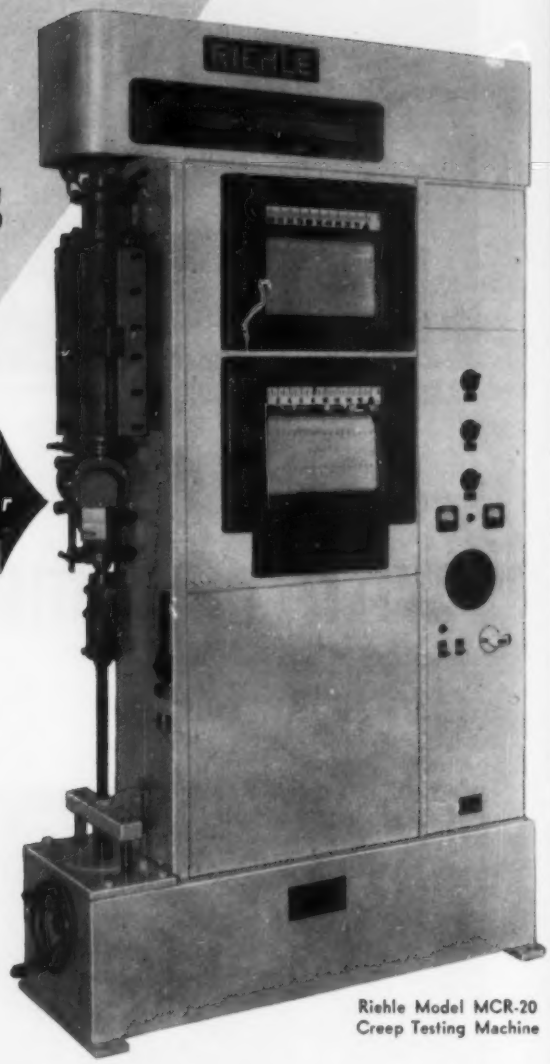


This direct-fired furnace has a rated production of 2500 lbs/hr of aluminum blocked forgings.

High temperature creep and relaxation TESTING MACHINES ... complete from RIEHLE®

New High Temperature Extensometer

Riehle extensometers are available in 28 different models to accommodate various specimens and temperatures up to 3500°F. Measuring ranges are from 0.1" to 0.5" and magnification ratios are from 20 to 1250, depending upon the type of recorder used.



Riehle Model MCR-20
Creep Testing Machine



Battery Installation of Riehle High Temperature Creep Testing Machines

Using only 33-1/3 lbs. of weights, this Riehle Model MCR-20 features a multiple lever loading system to provide testing loads in increments of 1,000 lbs. A sliding poise and beam graduated in units of 10 lbs. provides intermediate loads.

Riehle creep and relaxation testing machines are available in high temperature ranges of 1850°, 2200°, 3000° and 3500°F., and in capacities up to 450,000 lbs., as specially instrumented universal testing machine.

For saving time on vital projects, rely on Riehle. Contact this *one* source for ready-to-operate systems that include: (1) Basic Testing Machine, (2) Strain Measuring Instrumentation and (3) Complete High Temperature Accessories. Address DEPT. MP-259.

CREEP AND STRESS RUPTURE TESTING MACHINES • HYDRAULIC FATIGUE TESTING MACHINES • HYDRAULIC UNIVERSAL TESTING MACHINES • UNIVERSAL SCREW POWER TESTING MACHINES

Riehle® TESTING MACHINES

A DIVISION OF

American Machine and Metals, Inc.

EAST MOLINE, ILLINOIS

"One test is worth a thousand expert opinions"

APPLICATION and EQUIPMENT new products

Ultrasonic Welder

An ultrasonic seam welder that can weld sheets of dissimilar metals continuously has been announced by the Westinghouse Electric Corp. Sheets of metal to be welded are passed between two wheels vibrating at 20 kc. per sec. The periphery of these wheels presses against the



metals on opposite sides of the sheets. At the point of contact, the wheels break up the oxide coating on the metal surfaces and by a kneading action weld the metal lattices on the surfaces of the metals themselves. No electric current is passed through the spot being welded. A variable speed drive moves the metals through the unit as the weld is completed. With the experimental welder two sheets of aluminum 0.010 in. thick have been seam welded continuously at a rate of 15 in. per min.

For further information circle No. 218 on literature request card, page 48-B.

High-Temperature Alloy

A new family of iron-aluminum-manganese alloys has been announced by National Research Corp. Composition of the most promising alloy is 10% Al, 34.4% Mn, 0.76% C, balance Fe. The new steels are austenitic in structure and are about 15% lighter than carbon steel or 18-8 stainless and 20 to 25% lighter than the cobalt and nickel-base superalloys. They may be strain aged by heat treatment after cold working to provide higher strength and increased hardness. Oxidation resistance of the most promising new alloy has been shown adequate to 1500° F. Cold working properties approximate those of 18-8 stainless and permit cold forming by bending, rolling, swaging, drawing, stamping and similar operations. Machinability is approximately equivalent to that of 304 stainless steel.

For further information circle No. 219 on literature request card, page 48-B.

Carbon-Potential Control

Rolock, Inc. has announced a new type of automatic carbon-potential controller for use with endothermic gas generators serving controlled atmosphere heat treating furnaces and carburizing furnaces. The controller continuously measures the temperature at a single point inside a small flame, burning a sample of gas under constant pressure and with constant volume; to each carbon potential of the sample gas there is a corresponding flame temperature to which the controller can respond.

For further information circle No. 220 on literature request card, page 48-B.

Radiography

The Curtiss-Wright Corp. has announced a portable Puff camera for radiography. The small, light head and the flexible, light tubing permit insertion through small openings and

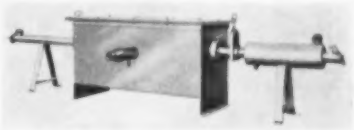


inspection of complex shapes and inaccessible areas. Four models offer sources of iridium 192 at a strength up to 30 or 100 curies or cobalt 60 at up to 2 or 10 curies. The source is propelled by compressed air.

For further information circle No. 221 on literature request card, page 48-B.

Tube Furnace

The Hevi-Duty Co. has announced new carbon-resistor tube furnaces capable of attaining temperatures to 5000° F. They are available in six standard sizes ranging from 1 by 12-



in. to 5 by 48-in. internal heated length. An automatic saturable-reactor system controls and regulates furnace temperatures. Two hours is required to reach 5000° F. Gates on both ends of the heated zone minimize radiation losses into the charge chamber and cooling chamber.

For further information circle No. 222 on literature request card, page 48-B.

Furnace Fixtures

General Alloys Co. has announced a fixture used in a large vertical drop-bottom furnace which will support 10,000-lb. loads at temperatures up to 1500° F. or 3000-lb. loads to 1900° F. The fixture, 5 ft. in diameter by 16 ft. high, is completely cast from X-ite. Tubularform design eliminates corners, edges and intersections where failures occur.

For further information circle No. 223 on literature request card, page 48-B.

Metal Removal Torch

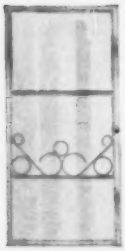
An automatic torch which uses an electric arc to melt metal and a jet of compressed air to blow the molten metal away has been announced by Arcair Co. One of the uses of the torch is to prepare joints for welding. The unit consists of a head with an electrode feed mechanism which feeds consumable copper-coated carbon-

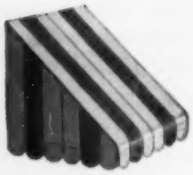
Amchem Alodine...



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PROTECTIVE





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COATINGS

FOR ALUMINUM



If you fabricate aluminum products—painted or unpainted—Amchem Alodine can provide you with an effective and protective chemical conversion coating process of remarkable characteristics.

The Amchem Alodine process forms an amorphous coating which becomes an integral part of the metal, enhances the natural corrosion resistance of the aluminum and provides an excellent bond for paint.

Alodine's simplicity, speed and economy as a prepaint treatment has gained widespread commercial acceptance in a wide variety of product applications.

Beyond product, Amchem provides the metalworking industry a complete service—processes, technical and engineering assistance, installation and instruction service—for corrosion protection, paint bonding, or other metalworking problems.

Write for complete information contained in Bulletin 1424A describing the uses of Amchem Alodine, as well as other literature pertinent to Amchem chemical conversion processes for the metalworking industry.



AMCHEM

AMCHEM ALODINE

Amchem Alodine is another chemical development of **Amchem Products, Inc.**, Ambler, Pa. • Formerly American Chemical Paint Company Detroit, Mich. • St. Joseph, Mo. • Niles, Calif. • Windsor, Ont./Amchem and Alodine are registered trademarks of Amchem Products, Inc.



graphite electrodes as required and supplies a jet of air at the proper location. The head is mounted on a tractor permitting straight-line or circular travel at predetermined speed. Where work is positioned, the Q-3 head can be removed from the tractor and mounted on the positioning equipment in the same manner as an automatic welding head. The head can be set at any angle with the work to produce a variety of grooves and bevel contours.

For further information circle No. 224 on literature request card, page 48-B.

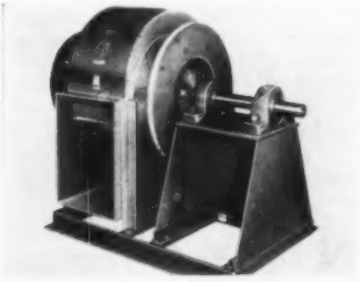
Nuclear Steels

A new series of steels for use in nuclear power plants has been announced by Jones & Laughlin Steel Corp. Manganese and cobalt are kept at an extremely low point. Other elements such as titanium are added, when needed, to provide the best combination of nuclear and mechanical properties. Nuclear steels can be produced as plate, sheet, strip, bars, tubing, rods, wire and extruded shapes, and can be welded and fabricated by conventional methods.

For further information circle No. 225 on literature request card, page 48-B.

Fans

A new line of high-temperature heat fans has been announced by the General Blower Co. Bearings are kept in cooler operating zones, preventing high temperatures inside the fan from



reaching the bearings. Dura-Temp fans have capacities from 600 to 30,000 cfm. and will handle temperatures up to 1650° F.

For further information circle No. 226 on literature request card, page 48-B.

Thermocouple Calibrator

A new thermocouple calibrator has been announced by Arcweld Manufacturing Co. The calibrator eliminates the stainless steel ice bath with test tubes and rack for cold junction compensation and replaces it with constant-temperature thermocouple reference junction. The unit is 40 by 30 by 70 in. and is equipped with



potentiometer, standard cell, null indicator, wet-cell storage battery for the potentiometer, 24-point rotary switch, Bureau of Standards calibrated platinum-platinum rhodium thermocouple calibrated on 12 points for temperatures to 2200° F., and furnace control instrumentation.

For further information circle No. 227 on literature request card, page 48-B.

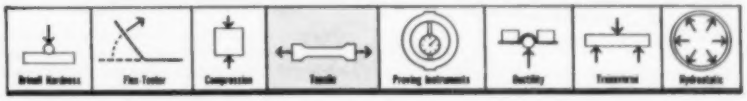
Casting Alloy

The Duraloy Co. has announced a new high-nickel alloy, Duraloy "Hom", which maintains high working strength at 2200° F. for many applications and usable working strength for selected applications at 2300° F. The alloy is resistant to oxidation at these temperatures. Static, centrifugal and shell molded castings can be furnished.

For further information circle No. 228 on literature request card, page 48-B.

Vacuum Brazing

F. J. Stokes Co. has announced production-scale equipment to utilize a new industrial-type vacuum brazing procedure, especially designed for brazing honeycomb structures in aircraft wings and tail surfaces. Units capable of handling panels up to 100 sq. ft. can be made. Brazing cycles run under 3 hr. from cold start to cold finish. With this equipment there is no need for making welded envelope enclosures for the work. The brazing



PORTABLE TENSILE TESTER

—You can take it with you!



With a Steel City Portable Tensile Tester, you can pull a tensile test wherever you want—in the field or in the shop. For shop or test trailer, everything but the pump can be wall-mounted to save space. It can be carried by two men and is rugged enough for moving in the shop or in the field.

Flat or round specimens, cast coupons or weld samples can be pulled apart with forces up to 40,000 lb. Tester is easily adjusted for specimens from 5 to 13 inches long. Wedge-type jaws for flat specimens; special V-type jaws for round ones. Hydraulic pressure built up with manual pump. Cylinder stroke is 1¾ in. Gage, 8½ in. OD, has maximum indicating hand.

Write or call Steel City if you have any testing problems.

•

Distributors in most major metalworking areas.

Steel City Testing Machines Inc

8811 Lyndon Ave., Detroit 38, Mich.

ACHESON

dispersions digest

Reporting uses for

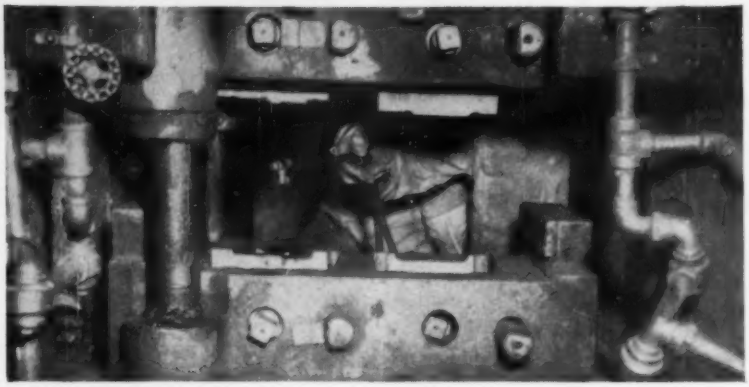
dag® BRAND DISPERSIONS

COLLOIDAL GRAPHITE, MOLY-SULFIDE, VERMICULITE, AND OTHER SOLIDS

COLLOIDAL GRAPHITE PROVES IDEAL AS FORGING LUBRICANT

Lubricants to be suitable for use on forging dies for steel and nonferrous metals must be stable under the high temperatures and pressures involved. Besides providing the most effective lubrication for hot-work dies, 'dag' brand dispersions act as coolants. Total advantages gained by using Acheson colloidal graphite, as described in the following applications are: improved quality of the forging, reduced die wear, lower production costs, and improved working conditions.

'dag' dispersion improves quality, cuts costs for Utica Drop Forge and Tool Division. With a large share of their capacity being devoted to the forging of jet engine blades, Utica finds it must maintain high production, consistently high quality, and a competitive price. Blade-forging dies have a comparatively short life due to rapid wear caused by the thinness of the blades, the high pressures required to form the heat-resistant alloys used, and the closer tolerances required. They have found that *every one* of these requirements can be met by using 'dag' colloidal graphite dispersed in water as their forging lubricant. First, it must withstand temperatures which range from 1950-2200° F. Sprayed on both halves of the die it forms a tightly adhering, smooth, microscopically-thin film that aids metal flow and substantially protects the die itself. In many cases, this has meant fewer finishing operations and therefore higher production, due to the improved quality of the blades. A compressor blade formerly required four blows from upset to finish, with an intermediate heat and tumbling operation. Now, this operation is done in only two blows from original heat. The savings . . . $16,000 a year on this part alone! Add increased life of these precision dies and you can appreciate what a 'dag' colloidal graphite dispersion means to efficient forging. Utica finds water-based dispersions best for press forging, and colloidal graphite in oil the best lubricant for hammers.



Operator spraying colloidal graphite on both top and bottom die halves before forging jet engine blades at Utica Drop Forge and Tool Division, Kelsey-Hayes Company.



Concentrated Acheson colloidal graphite being applied to die surfaces before they are put in service.

Pre-treatment and operational use of 'Aquadag' greatly increases die life. Before putting dies into service, a prominent midwestern manufacturer finds that by preheating them to about 250° F. and brushing on a dispersion of colloidal graphite in water, they have generally *doubled* the working life of their dies. When used as an operational lubricant, die wear on a truck body brace die was proved by actual measurements to be only *one-third* the former rate. And this was with 'Aquadag' diluted 1 to 240 in water! . . . Ample proof of the wide coverage, film toughness, lubricity, and basic economy of a "dag' brand dispersion.

Colloidal graphite is resistant to heat, does not react with the die steel, and the extremely small particle size permits an actual adsorption to the metal surface. A water carrier eliminates the usual smoke and fumes thus affording better working conditions and keeping die temperatures down. After the carrier evaporates, a dry graphite film remains which, besides being an efficient lubricant, protects the die from the accumulation of abrasive dust and scale. Die life is extended from 8 to 14 days and production increased by the reduction in downtime.

Specially compounded, ready-to-use forging lubricants containing 'dag' colloidal graphite are available from industrial lubricant suppliers. If you have a forging lubrication problem, it may pay you to call in your Acheson Service Engineer.

Write for additional information contained in Acheson Bulletin No. 426. Address Dept. MP-2.

ACHESON *Colloids Company*

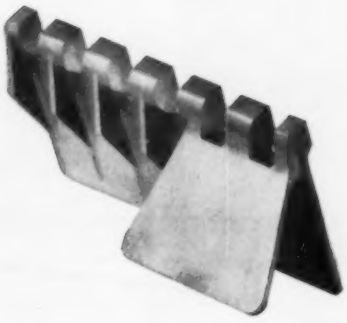
PORT HURON, MICHIGAN

A division of Acheson Industries, Inc.

Also Acheson Industries (Europe) Ltd. and affiliates, London, England

Offices in: Boston • Chicago • Cleveland • Dayton • Detroit • Los Angeles • Milwaukee New York • Philadelphia • Pittsburgh • Rochester • St. Louis

Rx



an
INVESTMENT
CASTING
of course

because investment casting means easier, more consistent, more uniform parts with higher properties at lower cost.

made of
RxMET ALLOYS
of course

because RxMET alloys give better, more consistent results through precise metallurgical control.

smart designer
smart producer

because both specify investment casting alloys by:

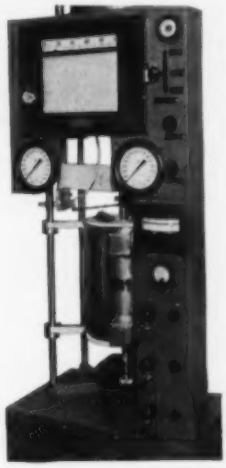
WAI MET
ALLOYS CO.
1999 GUOIN STREET
DETROIT 7, MICHIGAN

equipment operates at 1700° F. A high-vacuum atmosphere eliminates the need for inert gas.

For further information circle No. 229 on literature request card, page 48-B.

Creep, Stress-Rupture Testing

A new air-operated creep, stress-rupture testing machine has been announced by the Tinius Olsen Testing Machine Co. Variable loads to 12,000 lb. are applied without shock and maintained regardless of normal fluctuations in line pressure. Load is indicated by either of two precision



gages—one for the low range of 0 to 3000 lb. and the other for the high range of 0 to 30,000 lb. Specimens may be tested at any temperature from 0 to 1800° F. or 2000° F., which is automatically maintained by an electrically operated furnace, that swings in or out of the testing area. Stress-strain curves are plotted on the built-in recorder.

For further information circle No. 230 on literature request card, page 48-B.

Decorative Aluminum Sheet

The Aluminum Co. of America has announced Spangle Sheet, a new aluminum product for decorative applications. To produce Spangle Sheet, unusually large grains are induced in

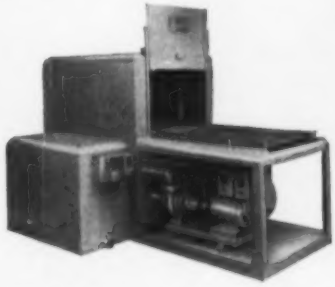


aluminum alloy sheet. Subsequent acid etching causes individual grains to stand out in relief. The action of the etch also develops mirrorlike

WORD FROM Waukee...

HOW TO USE DETERGENTS TO KEEP ENDOTHERMIC ATMOSPHERES *CLEAN!*

Recently we watched the operator of a carbonitriding furnace charge a basket of very oily work into his furnace while his boss, the plant metallurgist, stood by and sadly shook his head. "See, why we need a washer," he lamented. "We go to all the trouble to get a first class furnace, highly automated — we get a fine endothermic generator to provide atmosphere at a constant dew point — we buy a dew point recorder to keep track of what the generator is doing — we set up careful cycles so that our case depths are right to specs — then what do we do; we upset the furnace atmosphere with work covered with cutting oil."



Well, this was right down our alley because we make washing machines which fit in with any of the popular carbo-nitriders. Our little headline on how to use detergents to keep endothermic atmospheres clean is not as facetious as it sounds, and we think our metallurgist friend made a good point when he asked the question "then what do we do, we upset the furnace atmosphere with work covered with cutting oil!"

Waukee Power spray washers, putting a minimum of **a ton of hot detergent solution** a minute through the basket load of work will clean up those parts in jig time and keep the atmosphere clean! They do this for a matter of pennies per hour.

We have standard sizes to fit whatever furnace you have:

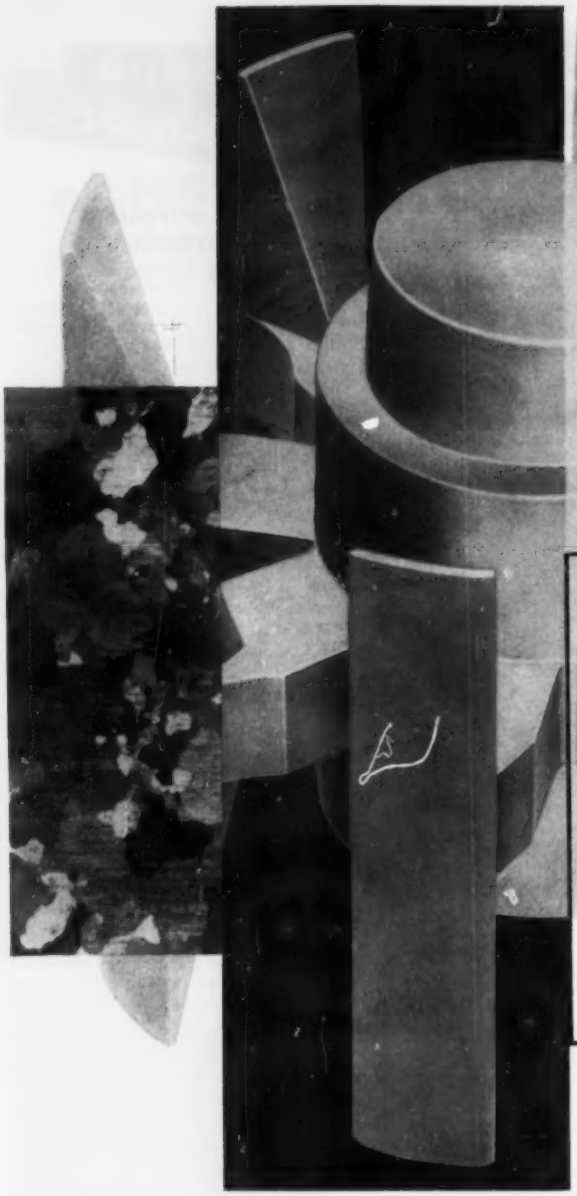
24 x 36 x 18 — 24 x 54 x 24
24 x 48 x 24 — 30 x 48 x 30
36 x 48 x 24

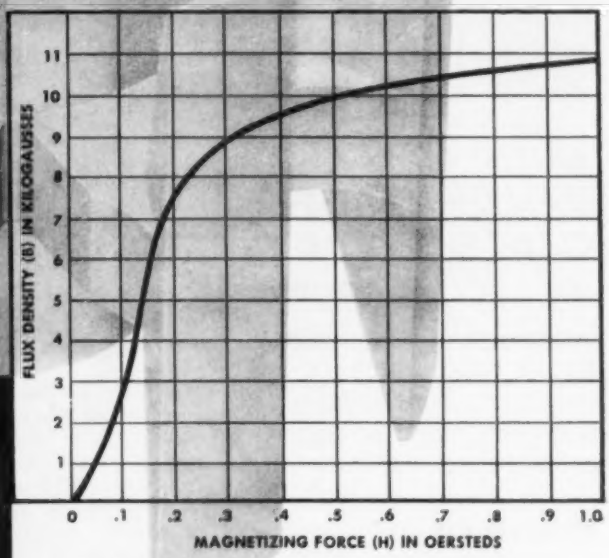
and larger.

Bulletin 1201 tells the story and we'll be glad to send you a copy Waukee Engineering Co., 5140 N. 35th St., Milwaukee 9, Wis.

R.C.O.

Waukee FLO-METERS
GAS-AIR MIXORS
ROTARY-VANE COMPRESSORS
INDUSTRIAL WASHING MACHINES





B-H curve for average precision cast Hipernik.

Investment casting eliminates costly machining of this Hipernik magnetic alloy hysteresis clutch.

Westinghouse Hipernik Casting

. . . cuts costs, retains magnetic properties

The field of electronics has created special metal problems. The Westinghouse Metals Plant has accepted and solved some of these problems.

Cast Hipernik® is particularly adaptable to the requirements of missile control systems. Other applications in the electronic control and instrumentation fields are transformer cores, pole pieces, solenoids, torque motors, magnetic clutches and many special magnetic applications.

The Westinghouse Metals Plant may be able to cut your costs by eliminating unnecessary machining, yet delivering to you a completely finished component ready for assembly. This modern metals plant can furnish strip, sheet and bar stock in other magnetic and high temperature alloys. Write to: Westinghouse Metals Plant, Blairsville, Pennsylvania. Our latest bulletin on Hipernik will be sent to you by return mail. J-05005

YOU CAN BE SURE...IF IT'S Westinghouse

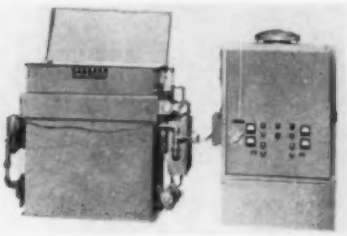
WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS-TV MONDAYS

facets on each grain. The new product is available in thicknesses ranging from 0.032 to 0.100 in. Maximum width is 36 in. and maximum length, 96 in.

For further information circle No. 231 on literature request card, page 48-B.

Degreaser

Detrex Corp. has announced a new Soniclean degreaser which employs a frequency of 400 kc. and stabilized trichlorethylene, to remove all types

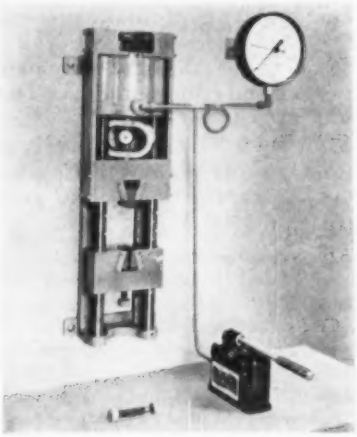


of soil. With the addition of adequate quantities of clean distillate, augmented by 2-micron filtration of the sonic chamber, this process is suitable for production cleaning.

For further information circle No. 232 on literature request card, page 48-B.

Tensile Tester

Steel City Testing Machines has announced a wall-mounted tensile tester. The only bench space required is for the 3 by 8 in. pump and reservoir base, and the manual pumping handle. Test specimens are gripped by hardened and ground jaws that



are wedge-shaped to insure positive grip. The stationary jaw holder can be adjusted for specimens from 5 to 13 in. long. The tester can be checked with a compression-type proving ring. Models are available with capacities up to 40,000 lb. Tests can be made on flat or round specimens.

For further information circle No. 233 on literature request card, page 48-B.

Conveyor Belts

Ashworth Bros., Inc., has announced new flat wire belts which are free rolling rather than sliding. They will carry heavier loads than flat wire or spiral woven belts. Built-in rollers turn on the connector rod. The connector rod is below the centerline of the belt which results in the roller face projecting on the lower side of the belt only, where it provides rolling friction without interference with the payload carried. The spacing of the rollers may be varied.

For further information circle No. 234 on literature request card, page 48-B.

Tool Steel

Darwin & Milner has announced that PRK-33 tool steel is available in three new sizes: 3 by 7 in., 4½ by 6 in. and 4 by 10 in. PRK-33 is used for high-production dies, shear blades, forming rolls, low-speed cutting tools, gages and knurling, burnishing and spinning tools. A D5 steel, its composition is 1.40% C, 13.00% Cr, 3.30% Co, 0.30% Mn, 0.60% Si, 0.50% Ni, 0.60% Mo, remainder Fe. PRK-33 hardens throughout to Rockwell C 64 after tempering.

For further information circle No. 235 on literature request card, page 48-B.

Admiral reports 70% labor savings . . ., 50% material cost reduction . . . 90% decrease in rejects on polishing operations with a

Hammond FLAT FINISHER

HERE'S WHAT THEY SAY

Admiral CORPORATION 3800 CORTLAND STREET CHICAGO

September 10, 1958

Mr. S. H. Miller
Hammond Machinery Builders, Inc.
1600 Douglas Avenue
Kalamazoo, Michigan

Dear Mr. Miller:

Since installing a Hammond Flat Finisher Model #FF8-1, we have been able to establish the following benefits:

1. A 70% polishing labor savings.
2. A 50% reduction of polishing material cost.
3. A 90% decrease of rejects caused in polishing.

Qualitatively, we feel this machine does a better job than by hand. It gives us a positive control over the same amount of surface material removed, and is easily able to meet all our production requirements.

As a result of this experience we feel that the purchase of the Hammond Flat Finisher has been a wise and profitable investment.

Yours very truly,
ADMIRAL CORPORATION
G. S. Roasle
VICE PRESIDENT, PRODUCTION

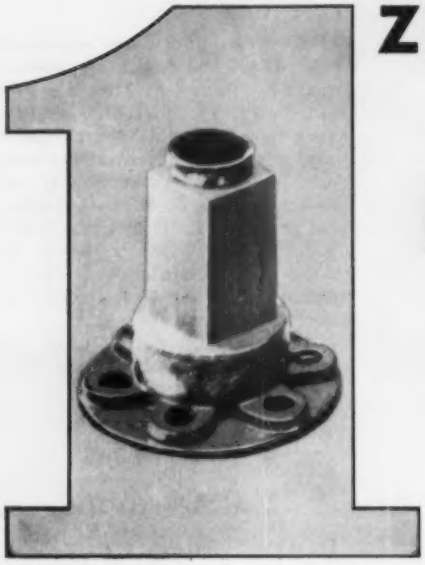


The above letter is typical of the reports we receive from users of Hammond Flat Finishers. For fast, uniform, economical finishing of flat work such as sheets, bars, strips, stampings and extrusions Hammond's are *second to none*. One operator grinds, polishes and deburrs on one machine in one operation. Available with 1 to 6 heads, 6" to 12" wide — handle work up to 6" high. Write for catalog.

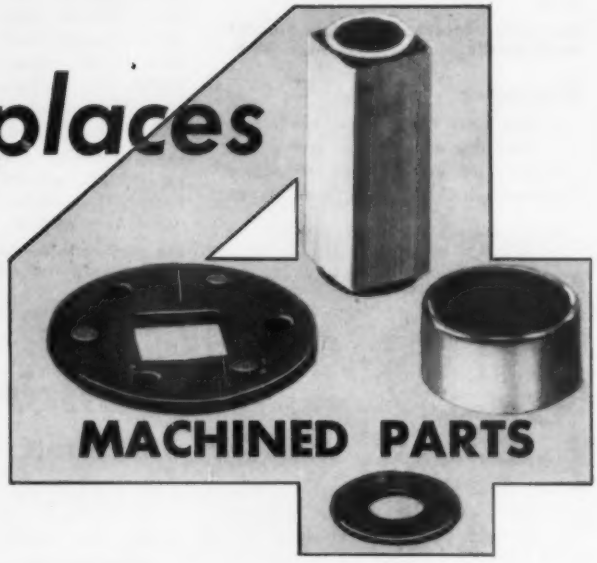
SEND SAMPLES
Send us one finished and several rough samples. You will receive a complete Engineering Report plus Production Analysis without obligation.

Hammond Machinery Builders INC.
1647 DOUGLAS AVE. • KALAMAZOO, MICHIGAN

ZINC DIE CASTING



Replaces



- *Eliminates Assembly*
- *Reduces Labor And Material Costs 50%*

This hub is part of the mechanism of coin-operated machines. Switching from brass and steel to a zinc die casting *slashed material and labor costs over 50%* for Chicago Coin Machine Division of Chicago Dynamic Industries.

Prior to the change, the 4-piece hub required 8 separate machining and assembly steps. The die casting however requires only 2; the casting is trimmed and the three assembly holes tapped. Scrap loss has been virtually eliminated, internal structural strength is fully retained.

The part is cast at a rate of 200 per hour in a 4-cavity mold and critical dimensions are held *as cast* to .005" overall, .003" concentricity. With annual hub requirements at 200,000, Chicago Coin Machine Division has found zinc die castings the way to meet today's rising production costs.

DIE CASTING is the Process

ZINC, the metal

BUNKER HILL



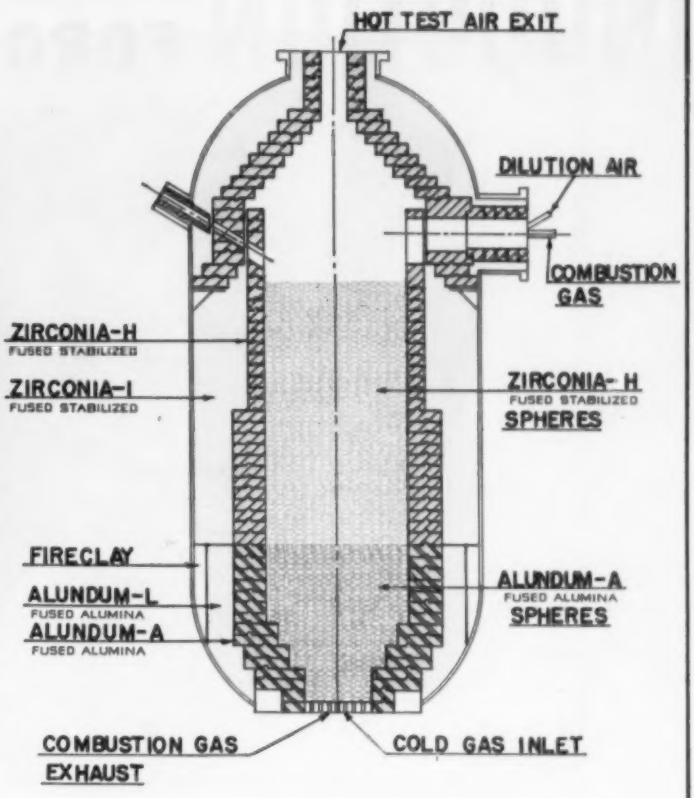
EASTERN SALES AGENTS
ST. JOSEPH LEAD COMPANY, 250 PARK AVENUE, NEW YORK 17

BUNKER HILL 99.99+% ZINC

SALES OFFICE FOR PACIFIC COAST
THE BUNKER HILL CO., 660 MARKET ST., SAN FRANCISCO, CALIF.



Newly Installed Pebble Heater at the Marquardt Aircraft Company of Van Nuys, California, designed to produce hot air for testing missile materials. *Combustion Inlet* shown above is lined with Norton Fused Stabilized Zirconia.



Aiding progress in high temperature testing . . .

Norton refractories provide high temperature insulation and heat transfer — at temperatures over 4000°F.

Norton refractories were specially designed to meet the high expansion and contraction conditions encountered in this new pebble heater. ALUNDUM* Fused Alumina and Fused Stabilized Zirconia refractories used for practically 100% of the construction of this unit and for the pebble bed protect against extremely high temperatures and provide maximum efficiency in heat transfer. As shown in the diagram of the pebble heater — designed by Marquardt engineers — combustion gas, mixed with dilution air, enters at upper right. The input burner supplies 100,000 to 1,000,000 B.T.U. per hour over temperatures ranging from 200°F. to above 4000°F.

The intensely hot gas, after flowing through a pebble bed of Zirconia and ALUNDUM Fused Alumina spheres, exhausts below. Entering near this exhaust, ambient cold air passes up through the pebble bed, extracts the stored heat and leaves at the top of the heater. This hot air is used for testing the heat resistance of various missile materials.

A similar installation, using Norton-designed refractories, and operating intermittently, 2 cycles per day, has provided nine months of trouble-free service. ALUNDUM Fused Alumina and Fused Stabilized Zirconia refractories are among the very few materials with sufficient resistance to chemical, thermal and mechanical attack to be suitable for such operations.

If you have a problem involving high temperature insulation or heat transfer, or if you would like further details on Norton Refractories, write to NORTON COMPANY, Refractories Division, 321 New Bond Street, Worcester 6, Mass.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

NORTON
REFRACTORIES
Engineered... Rx ...Prescribed

Making better products . . . to make your products better

NORTON PRODUCTS Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electrochemicals — **BEBB-MANNING DIVISION** Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

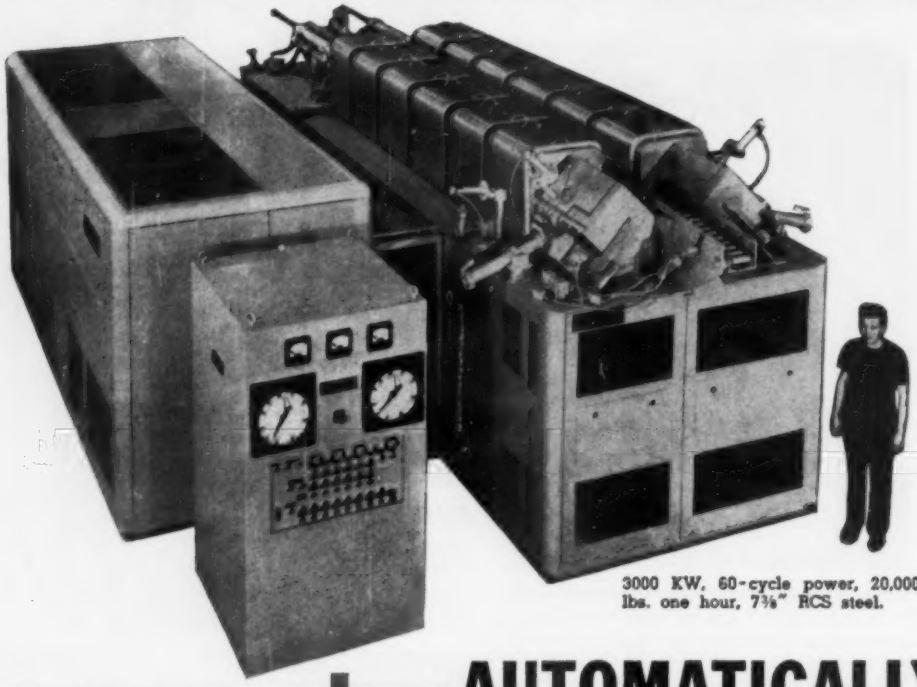
INDUCTION FORGING HEATERS

THAT

START

STOP

AND HOLD



3000 KW, 60-cycle power, 20,000 lbs. one hour, 7⅛" RCS steel.

AUTOMATICALLY

These induction heaters for steel forging billets differ from any forge billet heaters ever built.

- They are empty at the start—using only two or three dummy billets.
- They have an automatic clean-out—heats are easily segregated.
- They hold at the proper temperature and have automatic voltage regulation.

The heaters keep pace with the press . . . no need of building up a stockpile of heated billets. Completely automatic, the "Magnethermics" eliminate guesswork and deliver a billet at the proper temperature every time.

Magnethermic's engineers have studied forge shop practice for a good many years. If you are considering a modernization program in your forge shop, write Magnethermic for recommendations.

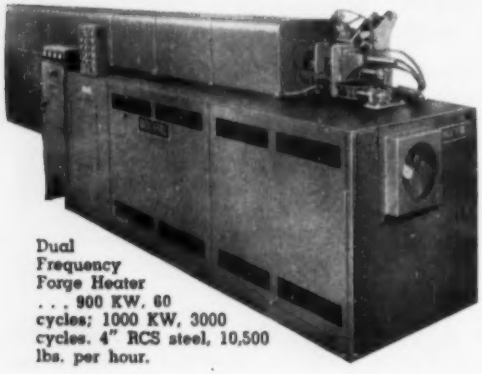


Movie Available on These Automatic Forging Heaters

16 mm, color; shows the complete cycle of operation. Write to Magnethermic and advise when you would like a showing.



Dual Frequency Forge Heater . . . 500 KW, 960 cycle; 500 KW, 60 cycle. 2" - 4" RCS steel, 6000 lbs. per hour.



Dual Frequency Forge Heater . . . 900 KW, 60 cycles; 1000 KW, 3000 cycles. 4" RCS steel, 10,500 lbs. per hour.

MAGNETHERMIC®
CORPORATION
3990 SIMON RD. • YOUNGSTOWN 7, OHIO

METALLURGICAL COMPETENCE: DO YOUR SPECIALTY STEEL SUPPLIERS HAVE IT?



How much confidence do you have in your supplier of specialty steels?

Here's why we ask. We've won over a number of new specialty steel customers in recent months because of our ability and desire to provide top metallurgical assistance. It's paid off for our customers in a number of ways: less rejects, less scrap loss and fewer specification revisions.

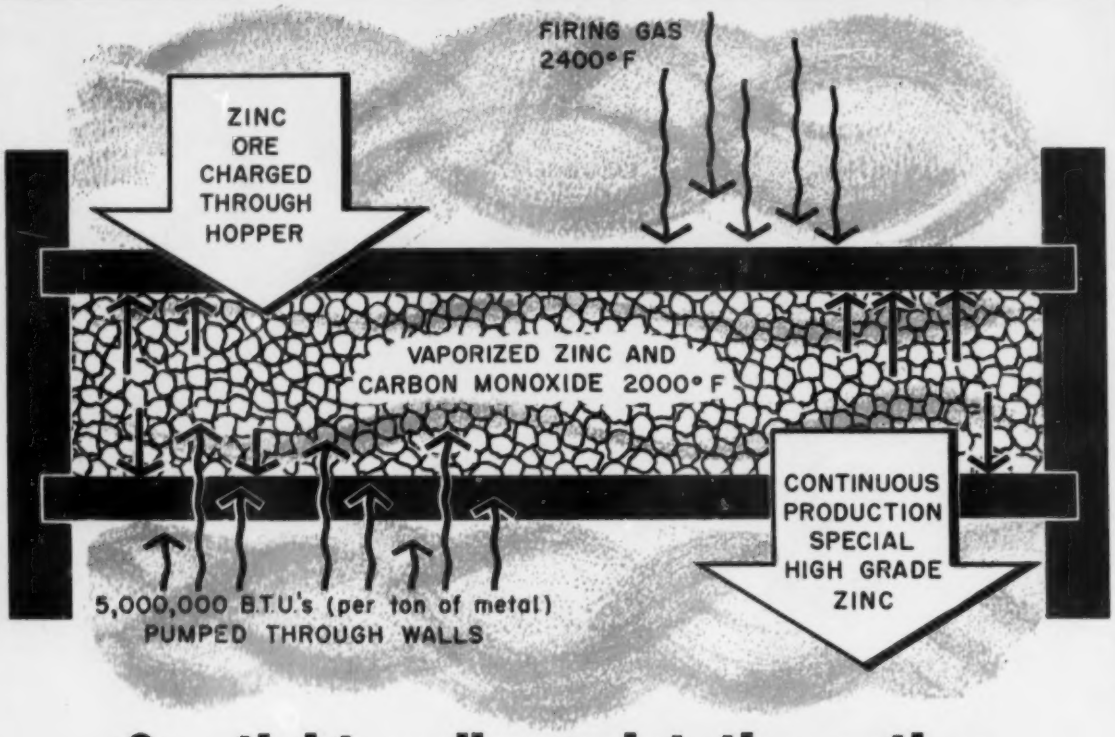
Our size of operation is an asset, too. Enables us to produce an end-product—AMBALLOY—uniform in quality, workmanship, and cleanliness. Amballoy enables users to restrict their necessary chemistries to a minimum. Proper heat treating economically matches metal to specs for those ultra-critical applications.

You can count on our metallurgical competence when you desire help with your material selection problems. If your confidence is shaken in your present supplier, contact us: A. M. Byers Company, Clark Building, Pittsburgh 22, Pennsylvania.

—personalized quality steels from a technically competent source

A. M. BYERS COMPANY

It was done with Carborundum's Super Refractories:



Gas-tight walls resist the action of zinc vapor and CO... transmit 5,000,000 BTU/ton of metal

A combination of heat, pressure, wear and corrosion in New Jersey Zinc's vertical retort process for the continuous reduction of special high-grade zinc presented a difficult job for Super Refractories by Carborundum.

This process requires a structural material with high heat conductivity, low permeability to contain the gas-vapor mixture, and high strength at very high temperatures. It must also be chemically inert to the combusted gases outside and the reduction products inside the retort.

One of Carborundum's Super Refractories—CARBOFRAX® silicon carbide refractory—met these tough requirements. It has high thermal conductivity (11 times better than fire-clay), almost complete impermeability to gases (2 cu ft of cold air/hr/sq ft/inch of thickness, at 1" water pressure), exceptional load-bearing strength at high temperatures (300 psi at 2750° F without crushing). CARBOFRAX bricks are chemically inert, too (they resist most acids, acid sludges and fluxes, zinc oxide or vaporized zinc), and are highly resistant to abrasion (grinding wheels are made of silicon carbide).

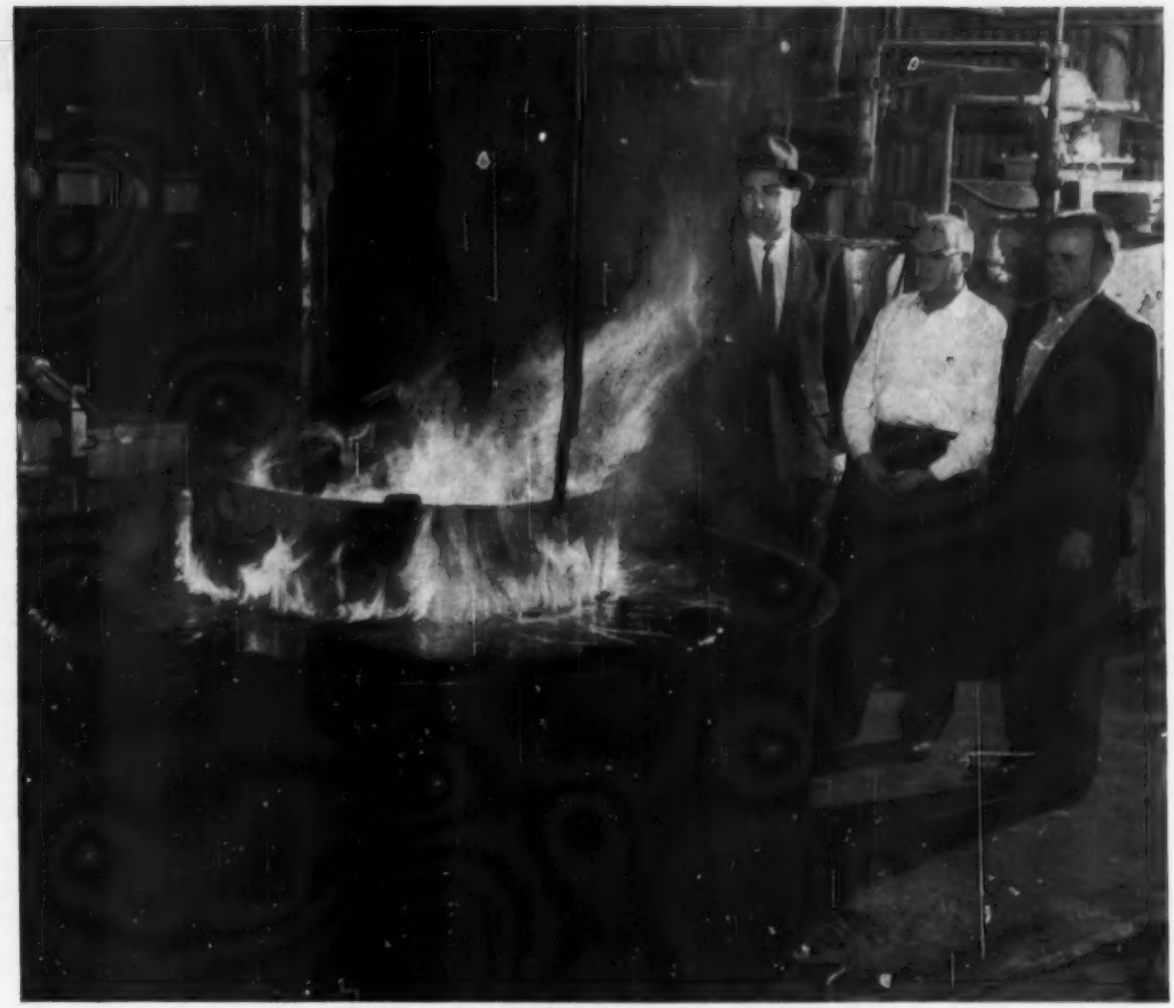
If you have a problem that even the best of standard refractories or metals won't handle, consider Carborundum's Super Refractories. There is a wide range of products, each with a combination of properties seldom found in other materials.

Write today for your free copy of "Super Refractories by Carborundum." The address: Dept. M-29, Refractories Division, Perth Amboy, New Jersey.



CARBORUNDUM

Registered Trade Mark



UNIFORM HARDENING WITH 2/10 RC VARIANCE ON 4340 SAE STEEL is assured by Gulf Super-Quench in this Ipsen furnace at Superior Heat Treating. Left to right: E. V. Hatton, Gulf Sales Engineer; E. Dominy, Treasurer; C. E. Perkins, Vice President of Superior Heat Treating.

Superior Heat Treating Company of Fort Worth reports:

"NEVER A REWORK WITH GULF SUPER-QUENCH!"

"We get consistent uniformity of hardness, piece after piece, using Gulf Super-Quench in our tanks," says Mr. C. E. Perkins, Vice President, Superior Heat Treating Company, Fort Worth, Texas.

"Never a rework on aircraft parts of 4340 SAE steel, which must be brought up to 50-53 Rockwell," says Mr. Perkins. "When we test one part that has cooled in Gulf Super-Quench, we can be sure the other parts are of the same hardness within our tolerances. That includes both high and low alloy steels."

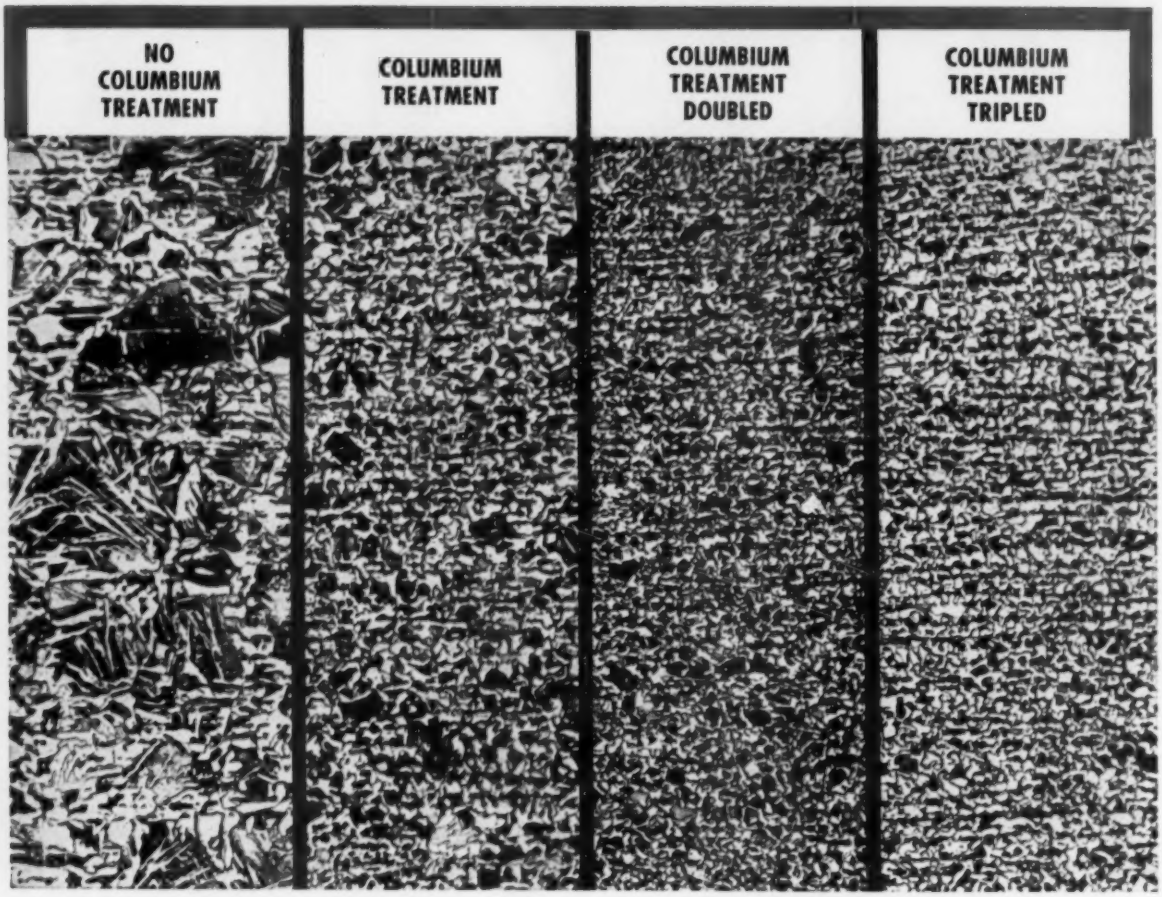
What accounts for the unusual performance of Gulf Super-Quench? Unusual, dual-action properties! High initial quenching speed in the critical hardening stage. Slow cooling in the final distortion range. Result? Gulf Super-Quench gives you deeper, more uniform hardening and less distortion.

How about your quenching operations? See how you can cut rejects and increase profits with Gulf Super-Quench. Just call a Gulf Sales Engineer at your nearest Gulf office.

GULF OIL CORPORATION
Dept. DM, Gulf Building
Pittsburgh 30, Pa.

GULF

HOW GREAT LAKES



Composite of photomicrographs made from the same heat of mild carbon steel shows the effect of varying columbium treatments on the grain structure of the steel.

The Great Lakes Family of High-Strength Steels

N·A·X FINEGRAIN STEEL

Lets you design superior performance, longer life and less weight into your product. Many diversified applications.

N·A·X HIGH-TENSILE STEEL

Offers all the characteristic features of N-A-X Finegrain, plus greatly enhanced resistance to atmospheric corrosion.

GLX W

A series of fine grained, mild carbon steels. They have unusually high strength, toughness and weldability.

N·A·X N-A-XTRA STEELS

Quenched and tempered steels of excellent weldability and toughness, with yield strengths from 75,000 - 110,000 psi.

N·A·X HIGH MANGANESE STEELS

N-A-X High Manganese and High Manganese Special Killed. These steels give yield strengths up to 50,000 psi.

STEEL CORPORATION'S NEW GLX-W STEELS GIVE ... HIGH STRENGTH TOUGHNESS REDUCED COSTS

Key to the success of Great Lakes' new GLX-W Series of steels is the fine grained internal structure produced by treatment with columbium. This grain refinement also contributes to ductility. And in addition, the GLX-W Series' low carbon and manganese content assures excellent weldability with freedom from underbead cracking under all conditions.

COST AND WEIGHT SAVINGS

Where design permits the replacement of carbon steel with GLX-W steels, weight savings of 20 to 35 per cent, and cost savings of 10 to 25 per cent can be realized. When replacing alloy steels the cost savings can range from 25 to 35 per cent. These steels feature higher yield strengths, greater tensile strengths and increased toughness without costly heat treatments or extensive alloy additions.

The GLX-W Series is so priced that substantial cost reductions can be obtained by weight reduction over mild carbon steel. Cost reduction can also be obtained over alloy steels because of the lower price of GLX-W steels.

MANY USES FOR GLX-W STEELS

GLX-W steels are especially recommended for a broad range of applications in mobile equipment and pressure vessels, as well as the transportation and construction fields.

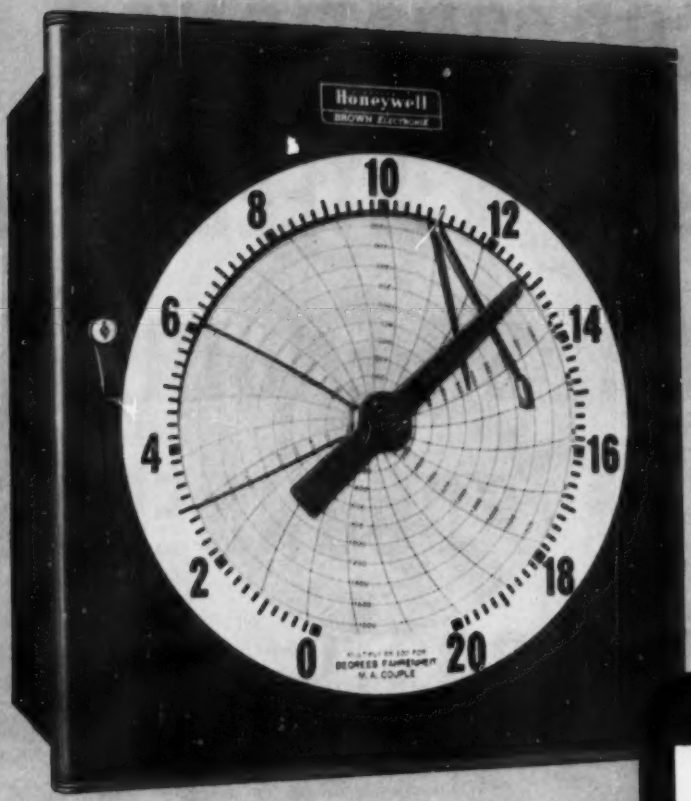
STRONGER AND TOUGHER

GLX-W steels are stronger and tougher than ordinary mild carbon steels and in some applications can do the job now being done by the more costly alloy steels.

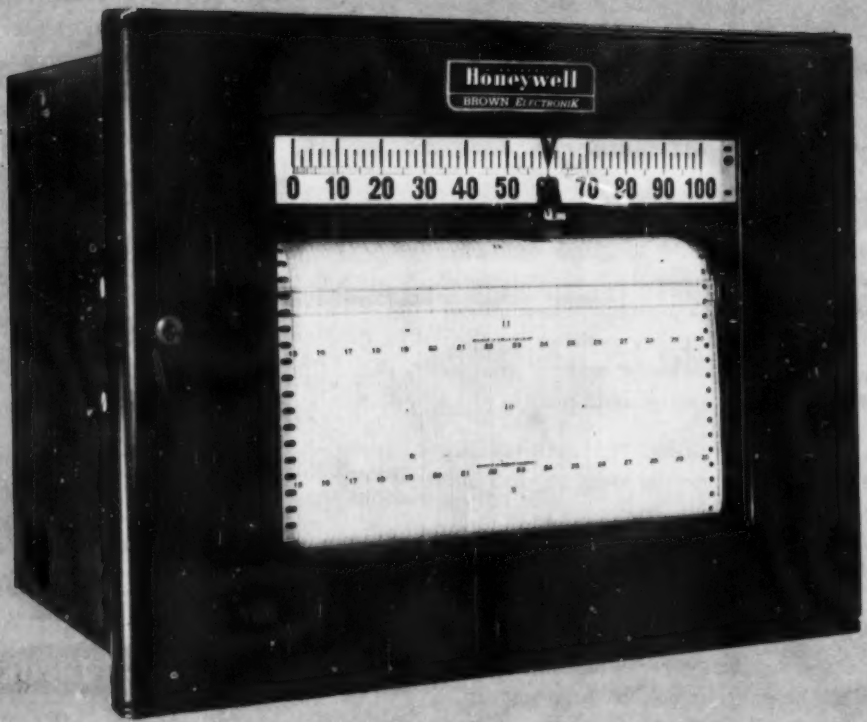
GLX
W

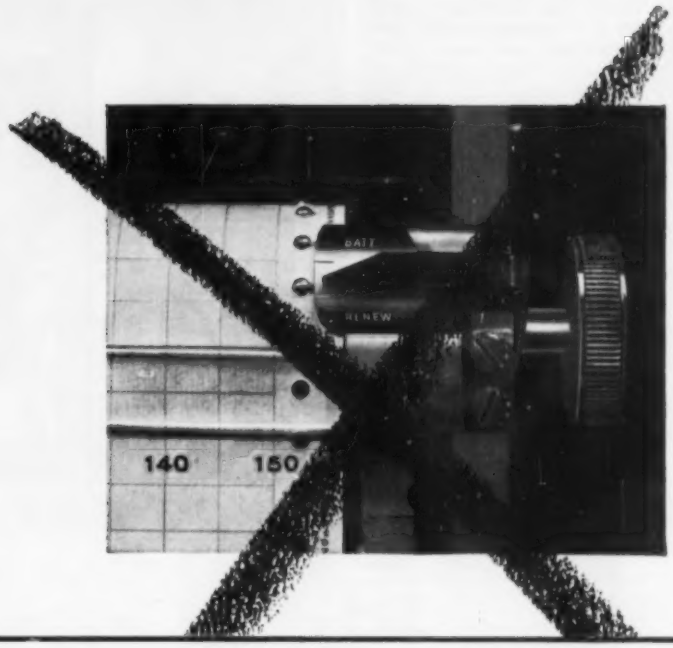
For additional technical information about these economical GLX-W steels write

Product Development Division, Dept. B-1
GREAT LAKES STEEL CORPORATION
Detroit 29, Michigan • Division of
NATIONAL STEEL CORPORATION


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NO BATTERIES OR STANDARD CELLS

in *ElectroniK* potentiometers

The new Honeywell Continuous Voltage Stabilizer makes batteries, standard cells, and standardizing mechanisms unnecessary in new Brown *ElectroniK* circular or strip chart potentiometers. This new unit accurately regulates the D-C reference voltage supply to the measuring circuit. Standardization is no longer necessary.

The small, compact stabilizer unit uses Zener diodes and an ambient temperature compensator to deliver a constant rectified voltage from line supply. This assures uninterrupted response to changes in the measured variable.

The Continuous Voltage Stabilizer means more dependability, less maintenance, continuous attention to the measured variable, and still another reason why *ElectroniK* instruments are your best value in measurement and control. These improved *ElectroniK* instruments will be available for delivery April 1. Get full details from your nearby Honeywell field engineer... he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Honeywell

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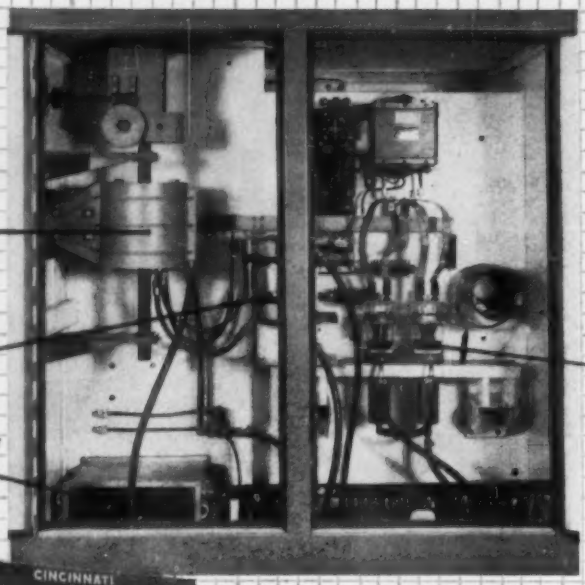
First in Control

A dividing wall separates the oscillator section (shown at right), from the power supply section (shown below). Door interlock switches are used on all access panels. All components are readily accessible and arranged for easy maintenance.

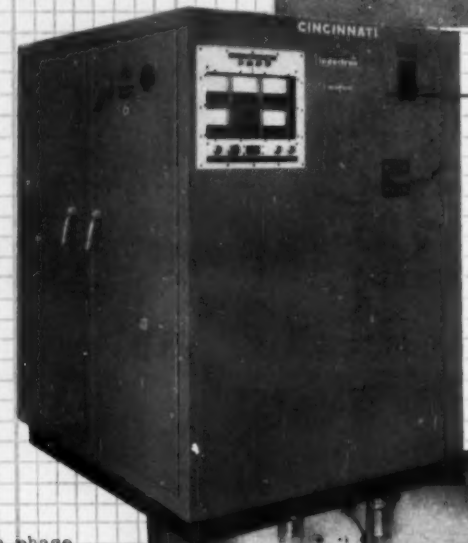
With this variable output RF transformer, output can be varied under load from 30% to 100% rating by positioning one dial.

Simplified, high KVA rated tank circuit includes vacuum capacitors for lowest possible power loss.

Cabinet air is cooled by water heat exchanger and blower. Air and water temperatures are thermostat controlled.



New type, extra-rugged duty low Mu oscillator tubes are especially designed for rugged industrial use. Filament supply to these tubes are both voltage regulated at ± 1% of nominal and ± 3% over a 27% line supply variation, and current limited to 200% inrush. Rectifier filaments also receive the same regulated supply. This insures longest tube life.

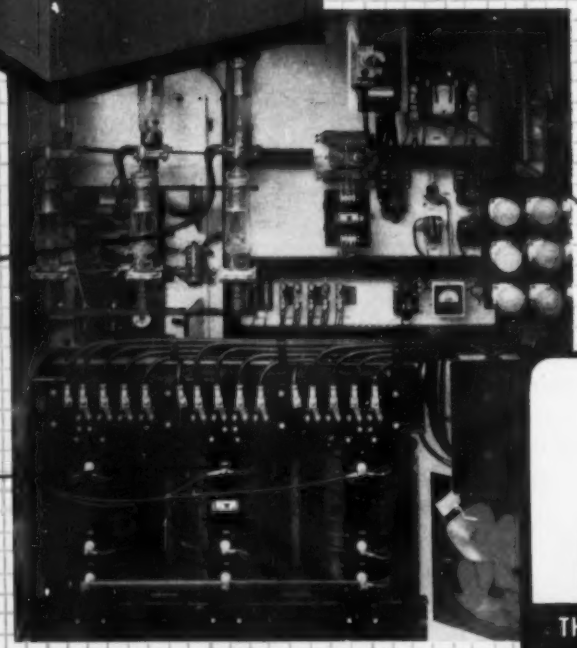


Here is the 30KW Cincinnati Inductron - operates at frequencies of approx. 1200KC. Also built in 15KW and 50KW capacities. A compact, self-contained, one cabinet unit.

Important Note to Users of Induction Heating Equipment

The CINCINNATI INDUCTRON has the design that provides for highest operating efficiency - maximum component life - easiest, lowest-cost maintenance. Check these features-

All controls are panel mounted, providing easy access for inspection and maintenance. Controls provide a more complete cross-section indication of the operation of the circuit than any other induction heater in the field.



Three phase, full wave bridge rectifier circuit uses industrial-type, heavy duty mercury vapor rectifier tubes. Tubes are arranged for even, forced air cooling.

Complete encapsulation against moisture and dirt, plus pie-type secondary windings, and even, forced air cooling, insure long life for the plate supply transformer.

For detailed information, call in a Meta-Dynamics Division field engineer.

inductron
flamatic
hardening machines

META-DYNAMICS DIVISION
Machines for Metal Forming and Heat Treating

THE CINCINNATI MILLING MACHINE CO.
Cincinnati 9, Ohio, U.S.A.

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APPLICATION and EQUIPMENT new literature

236. Aluminum
24-page data book on high-strength aluminum-zinc-magnesium-chromium-titanium alloy. Properties, aging, corrosion. *Frontier Bronze*

237. Aluminum
16-page bulletin lists sizes, weights, lengths of aluminum in rod, bar, plate, sheet. Guide to selection, finishes, mechanical properties. *Ryerson*

238. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

239. Aluminum Extrusions
Folder lists alloys used, finishes, trade phraseology. *General Extrusions*

240. Aluminum Extrusions
Catalog of extrusion dies in stock. *Jarl Extrusions*

241. Aluminum-Iron Alloys
Technical Data Bulletin IND-18 on aluminum-iron alloys for applications requiring high quality, soft magnetic materials. *General Plate Div., Metals & Controls Corp.*

242. Annealing
Bulletin SC-146 on cycle annealing in atmosphere and direct-fired furnaces. Steels annealed and hardnesses obtained. *Surface Combustion*

243. Austempering
Bulletin No. 167 on mechanized salt bath installation for continuous heat treatment of farm tools. *Ajax Electric*

244. Beryllium
24-page booklet on beryllium. Graphs and charts with up-to-date facts on properties. *Brush Beryllium*

245. Bimetal Applications
44-page booklet, "Successful Applications of Thermostatic Bimetal", contains uses, formulas, calculations. *W. M. Chace*

246. Blast Cleaning
Complete information on Malleabrasive for cleaning and finishing. *Globe Steel Abrasive*

247. Brazing
16-page reprint on furnace brazing gives advantages of method, design factors and methods of handling assemblies and furnaces for brazing. *Electric Furnace*

248. Brazing
28-page catalog of brazing and soldering equipment with suggestions on setting up brazing lines to fit the product being joined. *C. M. Kemp*

249. Carburizing
Bulletins A-1 and A-2 on liquid carburizing. Equipment, bath make-up and maintenance, cyanide analysis. *Park Chemical*

250. Castings, Precision
4-page folder on small parts made by precision casting. Tolerances, alloys, configurations. *Casting Engineers, Inc.*

251. Centrifugal Castings
8-page brochure gives properties of most common grades of thermalloy centrifugally cast tube. Weight tables. *Electro-Alloys Div.*

252. Chromate Finishing
File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

253. Coated Pipe
4-page folder on new plastic-coated steel pipe and tubing. How it solves the problem of pipeline corrosion. *Republic Steel*

254. Controllers
New 12-page Bulletin 5A-12 on operation-schedule controllers. Uses and applications. *Foxboro*

255. Conveyor Belts
Report on service life of woven wire conveyor belts operating at temperatures of 2050° F. *Cambridge Wire Cloth Co.*

256. Copper Alloys
14-page bulletin lists properties, forms and composition of wrought copper and copper-base alloys. Corrosion resistance, annealing range and fabricating properties. *Western Brass*

257. Corrosion of Copper
32-page reference booklet to aid in selecting copper alloy best suited for particular corrosive condition. 187 applications. *American Brass Co.*

258. Corrosion Testing
Data on corrosion test cabinets. *G. S. Equipment Co.*

259. Creep Testers
Data file lists 8 models, gives salient features and illustrates them and uses. *Arcweld Mfg.*

260. Cutting Oil
New folder describing nine types of cutting oils for varied uses. *Gulf Oil*

261. Cutting Oil
Bulletin 39 on transparent cutting oil which is designed for use on a wide variety of steels. *Sun Oil Co.*

262. Degreasers
Folder on vapor and solvent degreasers describes equipment and advantages. *Randall Mfg.*

263. Degreasing
Booklet on vapor degreasing. Design, installation, operation and maintenance of equipment. *Circo Equipment*

264. Die Steel
Data sheet on Huron high-carbon, high-chromium die steel. Applications, forging, annealing, hardening, tempering, properties. *Allegheny Ludlum*

265. Electric Furnaces
8-page Bulletin 570 on heat treating, melting, metallurgical tube, research and sintering furnaces. Custom designs for special requirements. *Pereny*

266. Extrusions
Booklet describes advantages of Cold-Prest impact extrusions, design considerations and methods of production. Alloys used. *Mueller Brass*

267. Fabrication
Booklet on welded steel heavy fabrication pictures and describes how various products are made. *R. C. Mahon*

268. Fans
Bulletins HF 100 and HF 100-A on heat fans. Selection and performance tables. *General Blower Co.*

269. Ferroalloys
Folder on ferromanganese-silicon gives its analysis and advantages. Calculations of cost savings. *Electro Metallurgical Co.*

270. Ferroalloys
New list of ferroalloys for additions of chromium, silicon, manganese, vanadium, columbium, boron, titanium. Special foundry alloys, vanadium metal, silicon metal, aluminum alloys. *Vanadium Corp.*

271. Film Thickness Tester
Data sheets give ranges, principle of operation of nondestructive thickness tester. *Unit Process Assemblies*

272. Finishing
New bulletin on Unichrome coating 6400, a vinyl coating with the appearance of leather. Coating procedure. Advantages. *Metal & Thermit*

273. Flame Hardening
Publication No. M-2015 on precision flame hardening machine with automatic operation. Specifications, design. *Cincinnati Milling Machine Co.*

274. Force Measurement
New booklet on modern industrial techniques for measuring force, weight, pressure. Advantages of electronic force measurement. Use of SR-4 strain gages in force measurement devices. *Baldwin-Lima-Hamilton*

275. Forging Machinery
32-page book No. 165 on design of dies for upsetting forging machines also includes machines, representative parts, tables of decimal equivalents. *Ajax Mfg.*

276. Forgings
Folder on facilities for production of flat-die forged products. Electronic equipment used. *Smith-Armstrong*

277. Freezer
Data on chest for use down to —140° F. for production and testing. *Revco*

278. Furnace Controls
Bulletin 658 on saturable reactor for regulation and control of electric ovens and furnaces. *Sorgel Electric Co.*

279. Furnace Fixtures
16-page catalog on baskets, trays, fixtures and carburizing boxes for heat treating. 66 designs. *Stanwood*

280. Furnaces
Bulletin 858 on carbon-resistor tube furnaces for temperatures to 5000° F. Uses, atmospheres, specifications. *Hevi-Duty Electric Co.*

281. Furnaces
New catalog on furnaces and ovens for laboratory or production. *K. H. Huppert*

282. Furnaces
Brochure describing heating, treating, processing and laboratory furnaces. *L & L Mfg. Co.*

283. Furnaces
12-page catalog on electric heat treating furnaces. Data on each of 57 models. Controls, instruments, elements and accessories. *Lucifer Furnaces, Inc.*

new **ANDREX**
140 KV x-ray unit

doubles x-ray output

4 ma instead of usual 2 ma
quicksteps through
twice as much work per day



full-bodied power

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x-rays 1¼" steel in 45 seconds

fine detail: with 1.5 mm focal spot
compact: will pass through a 6" opening
lightweight: 50 lbs. easy one-man load
won't overheat: motor-circulated oil insulation with thermal safety cutoff



full dress control

with "big machine" range and certainty

full-size MA and KV meters
(not mere makeshift "penetration" or "reference" meters)

range 50 to 140 KV
range 1 to 4 MA
} both under continuous control use *any* technic you want

direct operation off any power line
simply plug in on 110, 220, 380, 440, or 480 volt lines:
no extra autotransformers needed

fully weatherproofed
both head and control are gasket-sealed:
dustproof and waterproof
no separate "carrying case" to lug along

Picker x-ray

For details on this unit or any of the other machines or services listed below call any Picker Branch Office (see local 'phone book) or write

PICKER X-RAY CORPORATION
25 South Broadway, White Plains, N. Y.

one stop for everything in industrial radiography

ANDREX — portable x-ray units—130 KV, 140 KV, 160 KV, 200 KV, 260 KV

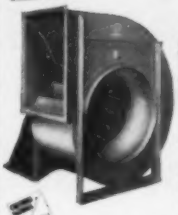
PICKER — x-ray units—35 KV Beryllium window, 90 KV, 150 KV (stationary and mobile) 270 KV portable, intensified—image fluoroscopes

TECH/OPS — units for isotope radiography—sources, equipment, containers for Iridium ^{192} Cobalt ^{60} Thulium ^{170} and Cesium ^{137}

ACCESSORIES — . . . films, tanks, darkroom sundries illuminators, *everything*

Top efficiency...Competitive costs
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NEW **INDUSTRIAL FANS**



AVAILABLE IN MULTIPLE WHEEL TYPES:
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- RADIAL BLADED
- AIR
- MATERIAL HANDLING

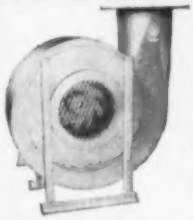
A type and design to serve any industrial application.

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A GENERAL BLOWER "FIRST"!
Capacity tables to show mechanical and static efficiencies for each point of operation! Write for details.

General
TURBO-PRESSURE BLOWERS

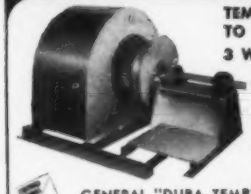
4 Oz. to 3 Lbs. PRESSURE 88 C.F.M. to 10,000 C.F.M.



Costless to operate . . . Deliver higher C.F.M. for a given H.P. with higher maximum efficiency. Available with corrosion-resistant coatings or stainless alloys.

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General
"DURA-TEMP" HEAT FANS



TEMPERATURES TO 1650° F
3 WHEEL TYPES
- FORWARD CURVE
- BACKWARD BLADE
- RADIAL ROTARY

GENERAL "DURA-TEMP" Heat Fans have acceptance by major kiln and industrial furnace manufacturers.

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General
BACKWARD BLADE, NON-OVERLOADING CENTRIFUGAL FANS
688 C.F.M. to 122,560 C.F.M., ⅛" to 12" S.P.
WRITE FOR BULLETIN BB-105

General Blower Company
DEPT. D • MORTON GROVE, ILLINOIS

284. Gas Plants
Data on anhydrous ammonia plants and standby gas plants. *Peacock Corp.*

285. Germanium
Bulletin on physical characteristics and purity standards of germanium and germanium dioxide used in making semiconductor devices. *Chemical & Metallurgical Div., Sylvania*

286. Gold Plating
8-page paper gives bath composition, equipment and operating conditions, and metallurgical characteristics of 24K gold plate on various base metals. *Sel-Rex*

287. Gold Plating
Physical, thermal, chemical, electrical, diffusion and optical properties of electroplated gold. Uses. *Technic*

288. Hardness Tester
Bulletin A-16 on microreflex hardness testers. Loads to 3000 gr. Zeiss optical system. *Gries Industries, Inc.*

289. Hardness Tester
Data on portable hardness tester with Rockwell and Brinell scales. *Mechanical Devices*

290. Hardness Tester
Catalog 72-1 on Leitz miniload tester for Vickers and Knoop hardness tests. *Opto-Metric Tools, Inc.*

291. Hardness Tester
Data on hardness testing scleroscope with equivalent Brinell and Rockwell C numbers. *Shore Instrument*

292. Hardness Testers
Folder on portable hardness testers for testing of various sizes, shapes and types of metal. *Newage Industries*

293. Hardness Testers
20-page bulletin on models, applications and how to use superficial hardness testers. *Wilson Mechanical Instrument*

294. Heat Treat Pots
Catalog on pressed steel pots for lead, salt, cyanide, oil tempering and metal melting. *Eclipse Industrial Combustion*

295. Heat Treating
Monthly bulletin on used heat treating and plating equipment available for immediate delivery. *Metal Treating Equipment Exchange*

296. Heat Treating Belts
42-page booklet on alloy steel belts for continuous high-temperature furnaces. Belt selection guide. *Wickwire Spencer*

297. Heat Treating Equipment
New 22-page booklet on equipment for heat treating metal in atmospheres. Descriptive diagrams and charts. *Lindberg Engineering*

298. Heat Treating Fixtures
Bulletin on formed and welded alloy heat treating furnace fabrications. *Alloy Engineering Co.*

299. Heat Treating Fixtures
32-page Catalog G-10A lists process equipment, heavy welded fabrications, muffles, trays, fixtures for furnaces, heat treating equipment, pickling equipment. *Rolock*

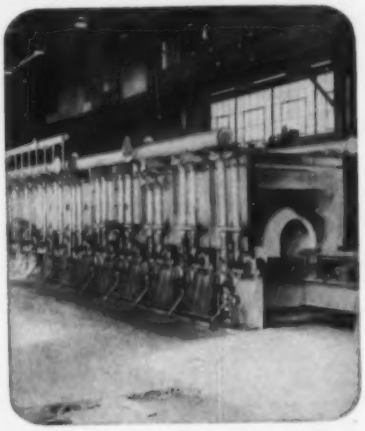
300. Heat Treating Furnaces
32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

301. Heat Treating Furnaces
Folder on industrial furnaces. Continuous designs. Insulation. *Pacific Industrial*

302. Heat Treating Guide
Chart guide constructed on slide rule

(*Continued on page 48-A*)

SPEED HEATING
SAVE SPACE
IMPROVE QUALITY
WITH HI-HEAD



R-S HI-HEAD HEATS 25 TONS SLAB PER HOUR..75% LESS FLOOR SPACE..ONE FOURTH LABOR

Now, heating of 25 tons of stainless steel slabs per hour is a continuous operation at Atlas Steels Ltd. The R-S Hi-Head Furnace reaches a high heat fast and maintains it uniformly in all parts of the furnace for the complete cycle. Heating time is reduced . . . there is no overheating of slab edges . . . and uniformity is assured on every piece. Labor is one-fourth that required on conventional furnaces. Floor space used is 75% less.

You can boost your "Quality Quota" if you heat with R-S Furnaces. For full technical details on faster slab heating write for the folder "Continuous Slab Heating."

R-S FURNACE CO., INC.
North Wales, Pa.
Car Hearth Furnaces
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Rotary Hearth Furnaces

R-S
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"Excellent Results Have Proved the Value and Versatility of Park's Non-Burning Carburizing Compounds"



Says L. A. Lindberg

President, Lindberg Steel Treating Co.
Chicago — Rochester — St. Louis
Los Angeles

"We have had excellent results with this Non-Burning Carburizing Compound for many years. For example, the pinion gear shaft that Milt Vandenberg is looking over has a heat treat specification of .040-.050" case depth and Rockwell 59-62 "C" Scale hardness.

"We process production quantities of these shafts in a two row, automatically controlled, pusher-type furnace using Park's Non-Burning (grade W) Carburizing Compound. The compound supports the parts during carburizing so that distortion is controlled and straightening operations are minimized. Tooth form and lead angle of the gear remain within the allowable tolerance and case depth is very accurately controlled.

"The value and versatility of this operation for such parts as well as for low-cost production items has been proved to us over the years. We have learned to depend on Park for uniformity and for service!"

Park NON-BURNING CARBURIZING COMPOUND is available in sizes No. 3, 6, and 8, and in two grades: "B" and "W". The latter grade is designed to minimize the possibility of copper migration on copper plated work. All sizes and grades are manufactured by coking a special quality coal in the presence of the energizing chemicals. This process produces a homogeneous compound and insures uniform carburizing activity even though usage reduces the material to pinhead size. Shrinkage rates are low and carburizing activity can be maintained indefinitely with addition ratios of as low as 1 to 10.

NON-BURNING is the quality carburizing compound that is economical to use. In addition to its uniformity and low replenishment requirement, it does not burn after removal from the furnace. NON-BURNING is especially suitable for carburizing alloy steel parts such as gears which are direct quenched or reheated. Send for the free, informative technical bulletin B-1, "Pack Carburizing of Steel in Solid Compounds".

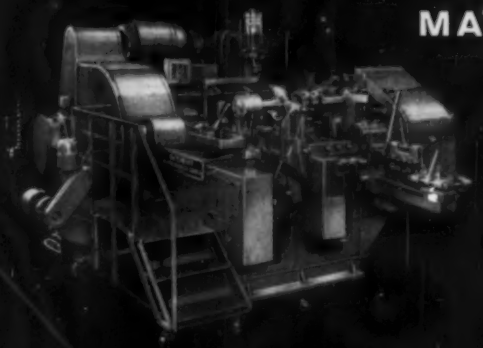
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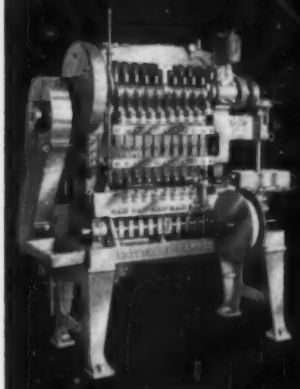
Woodside Rapid Carburizers (Non-Burning—Charcoal-Coke-Specification) • Park-Kase Liquid Carburizers • Quenching and Tempering Oils • Cyanide Mixtures • Neutral Salt Baths • High Speed Steel Hardening Salts • Iso-Thermal Quenching and Tempering Salts • Protective Coatings (No-Carb—No-Kase—No-Scale—No-Tride) • Carbon Products (Charcoal-Crushed Coke-Pitch Coke-Lead Pot Carbon) • Kold Grip Polishing Wheel Cement • Par-Kem Metal Cleaners • Cutting and Grinding Compounds (Kem-Cut—Kem-Grind—Blue Ice)

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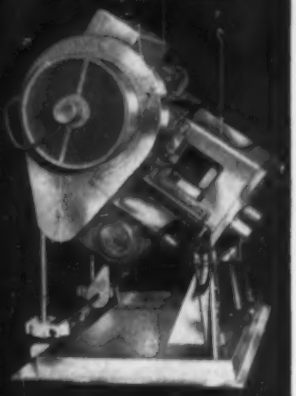
COLD HEADING
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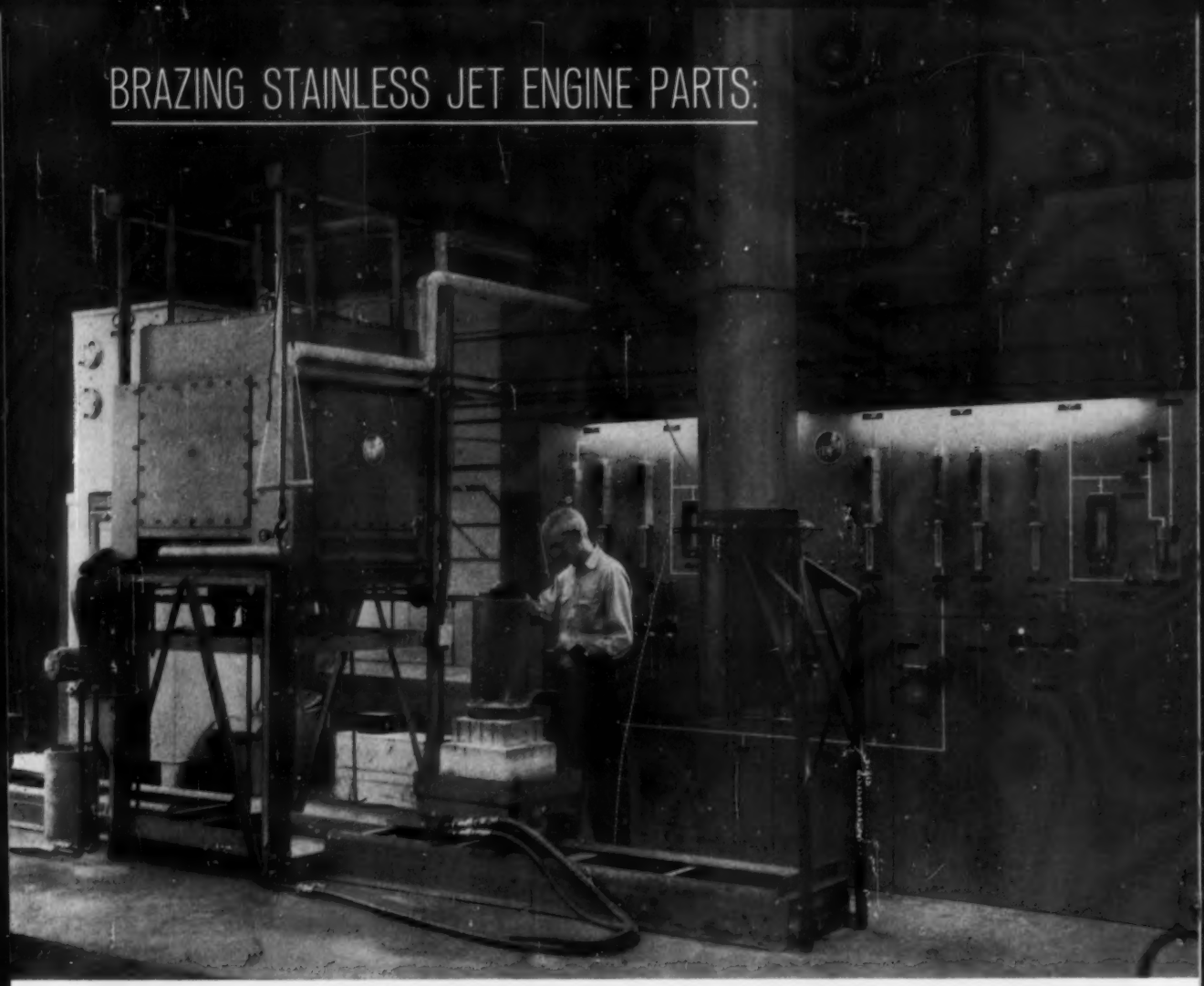


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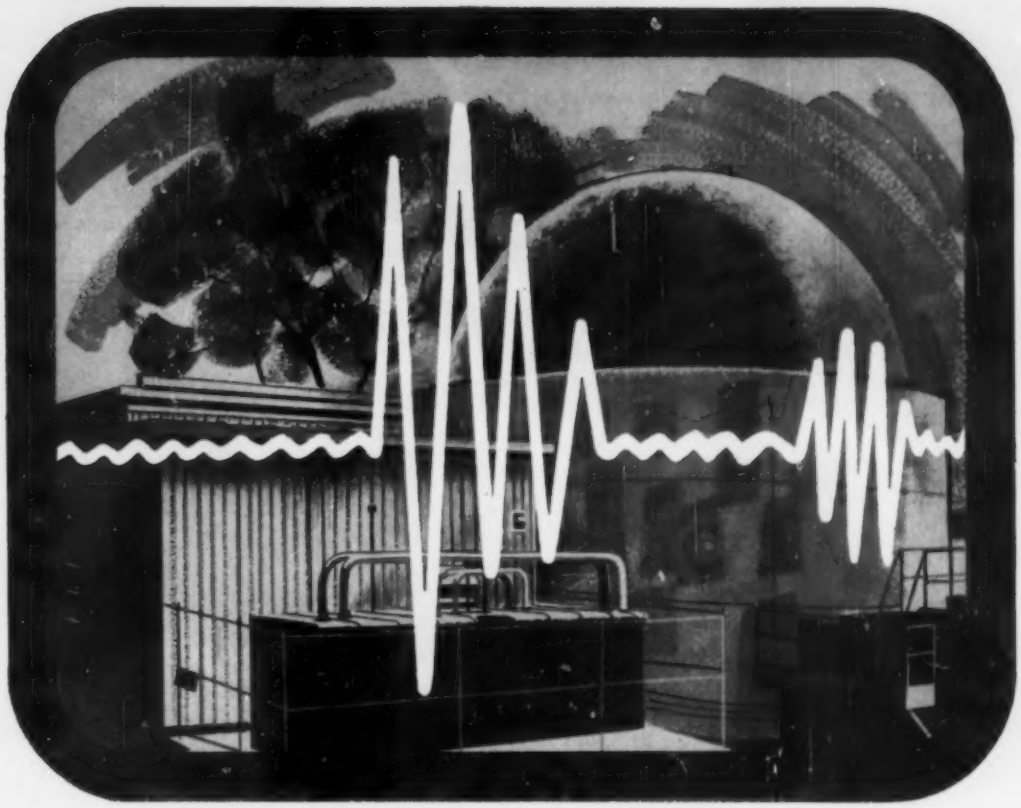
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When you first plan to braze, anneal or harden stainless steel parts, you'll find it pays to talk it over with a Harper representative . . . for Harper can build the furnace best suited to your needs: box, pusher, hump mesh belt, roller hearth, bell, elevator or pit.

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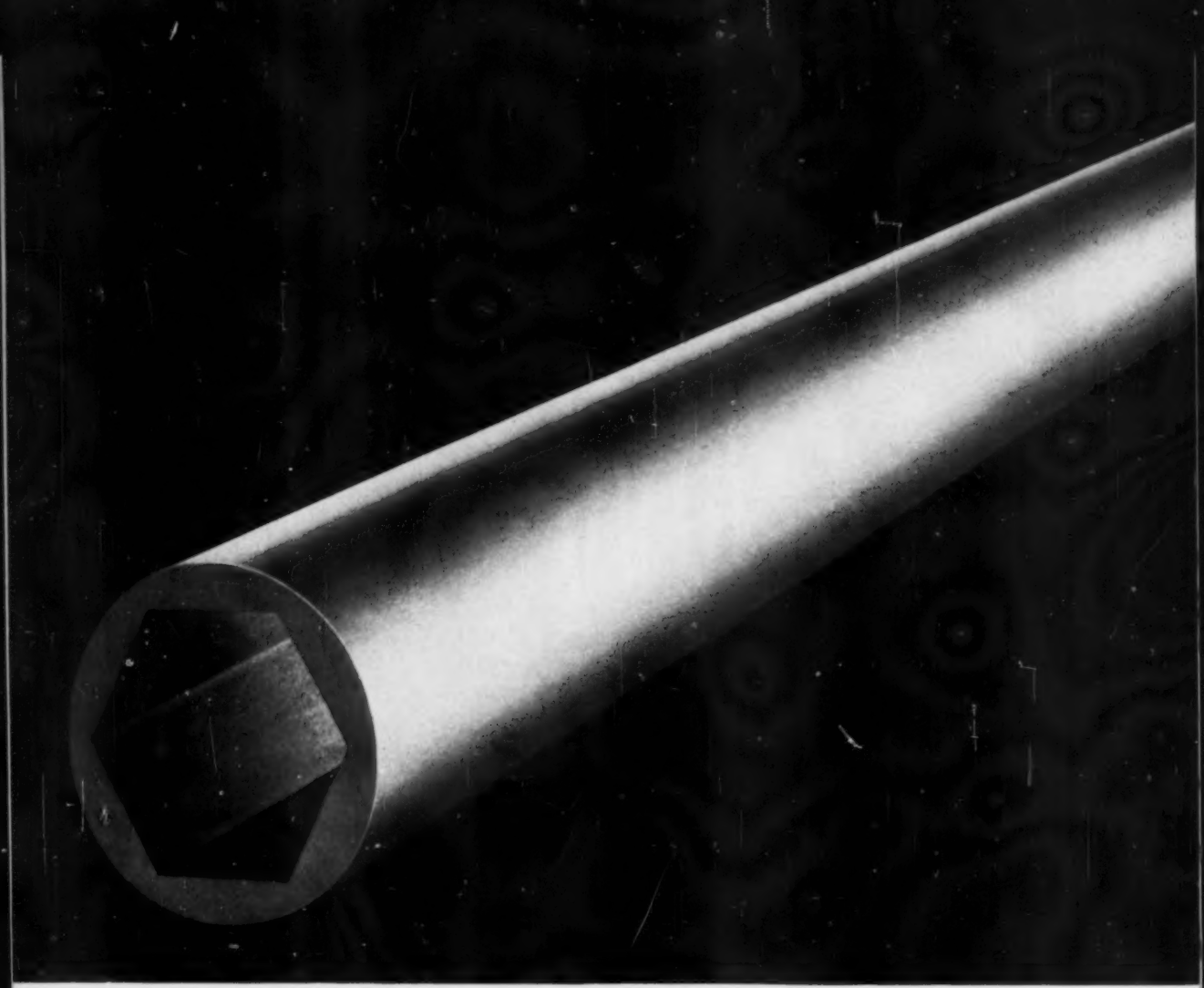
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(Continued from page 43)
principle for simplified hardening and drawing of tool steels. *Carpenter Steel*

303. Heaters
New Bulletin GER-1161 on immersion heaters for process use. Operation and maintenance problems involved. Applications. *General Electric*

304. High-Strength Steel
48-page book on T-1 steel, its properties and applications. *U.S. Steel*

305. High-Strength Steels
29-page discussion of progress being made toward higher strength alloy steels. Methods which increase strength of nickel-chromium-molybdenum alloy steel. *International Nickel*

306. High-Strength Steel
Folder on medium manganese copper-bearing high-strength steel. Properties. Corrosion resistance. *Youngstown Sheet & Tube*

307. High-Temperature Alloys
New 12-page booklet describes Nicrotung and W-545 superalloys for turbine disks and blades. Properties, structure. *Materials Mfg. Dept., Westinghouse Electric*

308. Induction Heating
12-page Bulletin 12B6430B on high-frequency induction heating. Specifications, applications, accessories. *Allis-Chalmers*

309. Induction Heating
Brochure on low-frequency induction heating. Advantages and applications. *Electric Arc, Inc.*

310. Induction Heating
8-page catalog section 22C on induction heating for forming and forging. Advantages. *Ohio Crankshaft*

311. Inspection
Bulletin on Spotcheck dye-penetrant inspection. Advantages, prices. *Magnaflux Corp.*

312. Inspection
16-page booklet on magnetic particle inspection. Equipment, uses, kinds of defects that can be found. *Magnaflux*

313. Inspection
Data on multi-frequency inspection of nonferrous and nonmagnetic metals. *Magnetic Analysis*

314. Iron Powders
6-page booklet on iron powders used in molding, welding, cutting and scarfing. Chemical analysis, physical characteristics. *Foote Mineral Co.*

315. Laboratory Equipment
New bulletin on cutting test specimens describes methods for different types of metals. Price list. *Sieburg Industries*

316. Laboratory Furnace
Data on nonmetallic resistor furnaces for research, testing or small-scale production. *Harrop Electric Furnace*

317. Laboratory Furnaces
Folder describes and illustrates tubular furnace for use in tensile testing, and control panels. *Marshall Products*

318. Lubricant
Bulletin 425 on colloidal dispersions for use in metal casting. Best formulas for achieving high lubricity and wetting action. *Acheson Colloids*

319. Machining Titanium
8-page bulletin on turning, milling, drilling, tapping, grinding. Recommendations for each. Typical properties of titanium. *Mallory-Sharon Metals*

320. Magnesium
53-page book on wrought forms of magnesium. Includes 44 tables. *White Metal Rolling & Stamping Corp.*

321. Metal Marking
New bulletin on all purpose electric pen which will arc etch any metal. *Newage Industries*

322. Metallograph
12-page bulletin on desk-type and research metallographs. Accessories, illuminating systems. *American Optical*

323. Metallography
12-page catalog E-29 describes bright-field equipment for visual observation and photography. *Bausch & Lomb*

324. Microhardness Tester
Bulletin describes the Kentron microhardness tester. *Torsion Balance*

325. Microscopes
40-page catalog on metallographs, metallurgical, toolmakers, stereoscopic, polarizing, phase and other microscopes. *Unitron Instrument Div., United Scientific*

326. Mixers
28-page booklet on four portable propeller-type mixers. Motors, propellers, mixing-heads, applications described. *Mixing Equipment*

327. Nondestructive Testing
8-page bulletin on equipment for nondestructive testing of bars, rods, tubing. *Magnetic Analysis*

328. Nuclear Forgings
6-page brochure on carbon, alloy and stainless steel forgings for nuclear reactor applications. *U.S. Steel Corp.*

329. Ovens
New 14-page Bulletin No. 53-CM on various types of core and mold ovens. Construction, operating principle, advantages. *Carl-Mayer*

330. Ovens
Bulletin 4-257 on gas, oil and electric ovens. Load carrying door, electric drawer and walk-in type ovens. *Grieve-Hendry*

331. Oxygen Analyzer
New Bulletin No. 0704-1 on continuous oxygen analyzer with automatic calibrator. Process applications. *Mine Safety Appliances*

332. Phosphate Coating
Bulletin on phosphate coating of iron and steel with Granodine. How applied. Chart gives coating time, weight, temperature range. *Amchem Products*

333. Polishing
6-page article in Metal Digest, V. 4, No. 3, discusses the effects of pressure in mechanical polishing. *Buehler, Ltd.*

334. Potentiometers
New 6-page Data Sheet E-33 (4) describing standardizing potentiometers for accurate thermocouple work. Design, specifications. *Leeds & Northrup*

335. Powder Metallurgy
Technical literature on high-density sintered metal parts. *Supermet Div.*

336. Powdered Iron
12-page Bulletin No. 2 on iron powders. Properties of Plast/Iron, Plast/Steel, Plast/Nickel, Plast/Manganese and Plast/Silicon. *Plastic Metals Div.*

337. Precision Casting
8-page bulletin on investment castings of various ferrous and nonferrous alloys. *Engineered Precision Casting*

338. Press Brake Dies
New 4-page bulletin describing roll form press brake die. *O'Neil-Irwin Mfg.*

339. Quenching
Bulletin 120 on use of heat exchangers to provide heat control in quenching bath. *Niagara Blower*

340. Radiation Badges
Folder on film badges for monitoring exposure to radiation. *St. John X-Ray Laboratory*

341. Radiography
New 16-page booklet gives principles of radiography, exposure calculations, methods of making exposures and design of units. *Princeton Div., Curtiss-Wright*

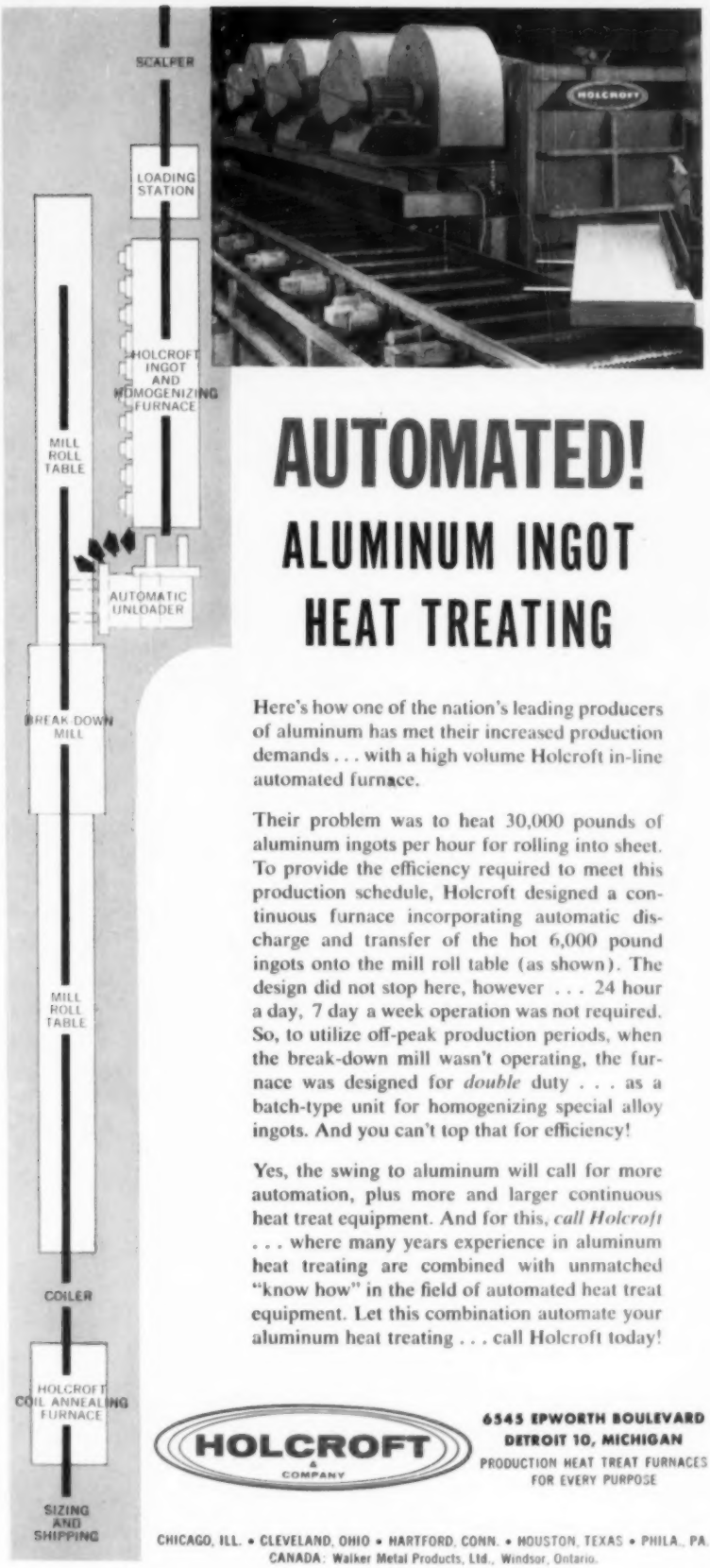
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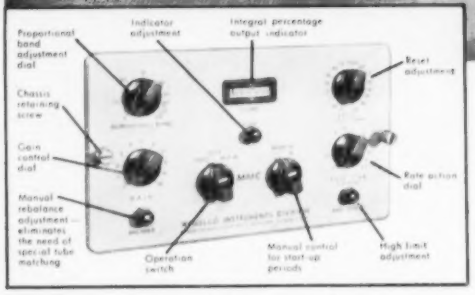
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other shapes. Technical data, tables, graphs, conversion charts. Properties. *Norton*

343. Resistance Material

16-page brochure on high-temperature electrical resistance heating material. Electrical, chemical and physical characteristics. *Kanthal*

344. Rolling Mills

Catalog FRM-58 on mills for laboratory and development. Wire flattening. Accessories. Formulas for selection of mills for strip and wire. *Fenn Mfg.*

345. Shotblasting

16-page "Primer on the Use of Shot and Grit". Problems of blast cleaning operations. *National Metal Abrasive*

346. Spectrographic Electrodes

New 24-page catalog S-58 on spectrographic graphite products describes manufacturing steps, shapes and designing of high-purity preformed electrodes. *United Carbon Products*

347. Sponge Iron

New 8-page brochure on HyL process for converting iron ore into sponge iron. Tables show ore analysis, sponge iron analysis, costs. *M. W. Kellogg Co.*

348. Spring Steels

48-page booklet on selection of spring steel. How it is made, hardness values, physical property data. *Wallace Barnes Steel Div., Associated Spring*

349. Stainless Fastenings

20-page catalog of stainless steel cap screws, nuts, washers, machine screws, sheet metal screws, set screws, pipe fittings and specialties. *Star Stainless Screw*

350. Stainless Strip

32-page brochure on 20 types of stainless strip steel. Recommended applications, chemical, physical and mechanical properties, corrosion resistance. *Superior Steel*

351. Steel Castings

New 36-page booklet on role of molybdenum in heat treated low-alloy steel castings. Effect on hardenability, tensile properties, fatigue, wear and impact resistance, machinability and weldability. *Climax Molybdenum Co.*

352. Steel Tubing

48-page Handbook F-3 on fabricating and forging steel tubing. Bending, shaping, cutting and joining operations described. *Ohio Seamless Tube*

353. Testing Machines

New 32-page Bulletin No. 54 on universal testing machines. Specifications, and loading, weighing and indicating systems. *Tinius Olsen*

354. Testing Machines

12-page catalog on ten testers including hardness, ductility, tensile, compression and transverse strength. *Detroit Testing Machine*

355. Testing Machines

New 28-page catalog on fatigue testing machines. Specifications, working principles. *Riehle*

356. Testing Machines

Bulletin on Brinell hardness, ductility, compression, tensile, universal, transverse, hydrostatic proving instruments. *Steel City Testing Machines*

357. Thermocouple Units

New 36-page Catalog 1885 on thermocouple assemblies. Assembly instructions, specifications, applications. Pressure and temperature ranges. *Conax Corp.*

358. Thermocouple Units

Bulletin No. TA-457 gives sizes, prices, ordering information. *Claud S. Gordon*

359. Thermocouples

Revised 8-page Catalog No. 32 on thermocouple and thermocouple wires. Charts on calibration symbols and wire color codes, wire resistance weights, properties. *Thermo Electric*

360. Tool and Die Steels

26-page book on six oil and air-hardening steels for high-production tools and dies. Uses. *Bethlehem*

361. Tool Steel

New reference chart listing brand names of 13 tool steel suppliers. SAE and AISI classification numbers. *Uddeholm*

362. Tubing

New Technical Data Card 186-A, "Guide To Specifications and Applications" of tubular products, fittings and flanges in various grades of steel. *Tubular Products Div., B. & W.*

363. Tungsten

20-page bulletin on manufacture, properties and uses of tungsten. Flow chart of tungsten production. *Sylvania Electric*

364. Tungsten Alloy

Bulletin on properties and uses of 90% tungsten alloy, balance nickel and copper. *Firth Sterling, Inc.*

365. Ultrasonic Inspection

Ultrasonic Inspection Newsletter, No. 2, contains article on immersion inspection of wing spars for jet fighters. *Sperry Products*

366. Ultrasonics

Data sheets on high-power ultrasonic generators for mass production, and ultrasonic scrubber. *Acoustica Associates*

367. Vacuum Furnaces

Data Sheet No. 4-30 on 5 to 50 lb vacuum furnace. Crucible capacities, pumping capacity, pre-pouring pressures. Techniques. *Rochester Div., CEC*

368. Vacuum Furnaces

Data on high-temperature high-vacuum retort furnaces. *General Vacuum Corp.*

369. Vacuum Melted Alloy

New 12-page Engineering Data Brochure BM-105 on vacuum melted alloys. Physical and mechanical properties. Tensile test data, heat treatment. Stress-rupture. *Metallurgical Products, G.E.*

370. Vacuum Metals

Folder on facilities for making induction vacuum melted alloys. Alloys available. *Allvac Metals Co.*

371. Vacuum Pumps

Data Sheet 510 gives specifications and design of high-vacuum pump. *F. J. Stokes*

372. Welded Assemblies

New 20-page catalog of welded precision assemblies, rings and bands. Metals used. *American Welding & Mfg. Co.*

373. Welding

New 12-page Pamphlet 2004 Ea on automatic flash welding machines. Advantages, applications. *ASEA Electric, Inc.*

374. Welding Electrodes

Series of reference data charts on welding electrodes and filler rod. Melting rates, efficiencies and recommended welding currents. *Ampco Metal*

375. Welding Steel Castings

52-page book on recommended practice for repair and fabrication welding of steel castings. 18 pages of tables. *Tempil® Corp.*

376. Wrought Alloys

New 48-page booklet shows heat and corrosion-resistant alloys are rolled and worked on a mass-production basis. *Haynes Stellite Co.*

377. X-Ray

12-page bulletin on gamma radiography tells how to select the source, equipment, techniques and fundamentals of gamma radiation. *Picker X-Ray*

378. X-Ray Microscope

New catalog includes micrographs, theory of operation and technical details. *General Electric, X-Ray Dept.*

379. X-Ray Supplies

Bulletin on X-ray films and chemicals for radiography. *Ansco*

FEBRUARY, 1959

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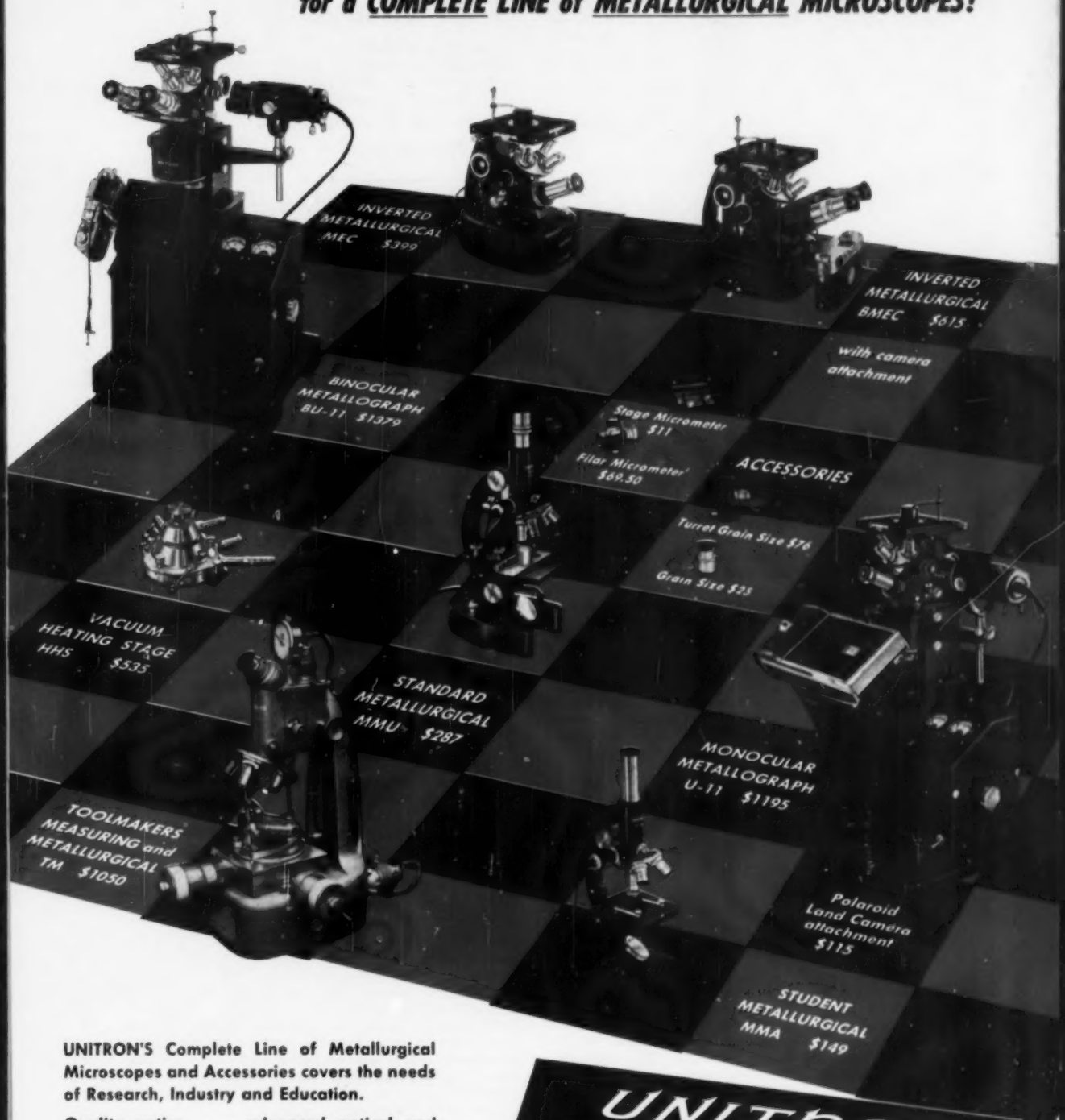
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by Carl F. Joseph
Technical Director

CENTRAL FOUNDRY DIVISION
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.....The metallurgy of strength and

The secret of a stronger iron casting lies in the composition, the melting and the heat-treating processes. Perhaps I should use some other word than "secret," because the fact is well known today, but in 1925, when we started our search for a stronger iron, the principle was well known only in respect to steel.

Our research led us to think that heat-treating could improve iron as well. After considerable experimentation, we learned how to arrest the malleablizing process to produce an improved pearlitic malleable iron . . . an iron that compares favorably with the properties of a good grade forged steel. It is from the words "Arrested Malleable iron with Steel-like characteristics" that the name "ArmaSteel" was coined.

The raw materials and melting process for ArmaSteel are very similar to those of our malleable iron . . . the major difference being in the heat-treat cycle. In the cupola, we melt steel scrap, ferrosilicon, and remelt. We add .0025% boron to the charge to assist in breaking down carbides during malleablizing.

Next, the molten iron is tapped into a forehearth where it is desulphurized with soda ash. This removes small particles of slag and impurities, thus improving machinability of the casting. After refining in an electric furnace, the iron is tapped into ladles.

To improve the physical properties on certain castings, .007% bismuth is added as a ladle inoculant: this stabilizes the carbides during the initial freezing of the metal. On heavy castings such as the Pontiac crankshaft, up to .02% bismuth is added. This bismuth-boron combination is a new development.

I mentioned before that the heat-treating of ArmaSteel greatly affected its properties. Actually, we use several different heat-treatments to produce the several ranges of ArmaSteel. All are alike during the malleablizing cycle, where the massive carbides are eliminated. Malleablizing requires about 20 hours: the castings are held at 1750°F. for 10 hours, and near the end of the cycle are dropped to 1650°F., after which they are air-quenched. Brinell hardness at this point is around 300.

Tempering brings the Brinell hardness down to customer's specifications. We produce two standard Brinell ranges of air-quenched and tempered ArmaSteel . . . BHN 197 to 241 (3.9-4.3 mm.), and 163 to 207 (4.2-4.7 mm.). The castings are tempered in a recirculating furnace. The harder material is in the furnace for a total of six hours and forty minutes, and is held at heat for three and one half to four hours at 1270° to 1290°F. The softer material uses the same time cycle but higher heat . . . from 1320° to 1340°F.

For automobile crankshafts, a special hardness range is used. The ArmaSteel is air-quenched and tempered, but the tempering is for six hours at 1200°F., which produces a harder material (BHN 217 to 269).

Two other types of ArmaSteel are produced by reheating the air-quenched castings to 1600°, holding at heat for thirty minutes, then oil-quenching. These are then tempered for three and one half hours at 1170° to 1190°F. BHN is 241 to 269 (3.7-3.9 mm.) and 269 to 302 (3.5-3.7 mm.).

I've gone into detail on heat-treating because it has such a great effect on mechanical properties. Tempering directly controls the amount of combined carbon in the matrix, and this in turn dictates how hard and strong the ArmaSteel will be . . . the higher the combined carbon, the stronger, harder, and less ductile the casting. Thus, the engineer can choose the combination of properties best suited to his application. I can best explain the results of this careful heat-treatment by giving you a brief list of the mechanical properties of ArmaSteel.

1. *Machinability* . . . Because of the carbon nodules in the pearlite matrix, the machinability of ArmaSteel is generally from 10 to 30 percent better than that of steel forgings of the same Brinell. Improvements of up to ten times longer tool life and three times more pieces per machine have been shown.

2. *Selective Hardening* . . . ArmaSteel responds readily to localized hardening, either by flame or induction methods. A minimum of Rockwell "C" 50 is obtainable on such parts as shifter yokes, rocker arms, and gears. Some applications use the lead immersion or hot salt bath methods, followed by an oil-quench.

3. *Bearing Properties* . . . ArmaSteel is such an efficient bearing material on a hardened steel shaft that bronze bushings are often eliminated. The automotive rocker arm illustrates this excellent non-seizing property in metal-to-metal wear.

4. *High Yield Ratio* . . . The oil-quenched and tempered ArmaSteel has a minimum yield strength of 80,000 psi and ultimate strength of 100,000 psi, making it ideal for highly stressed parts.

5. *Fine Machine Finish* . . . A mirror-like finish can be produced on ArmaSteel. Diesel pistons are an application where this fine finish reduces friction wear to a minimum.

6. *Damping Characteristics* . . . In both small engines and in automotive engines, ArmaSteel crankshafts exhibit a fine damping capacity that aids quiet operation.

7. *Wear Resistance* . . . ArmaSteel withstands excessive wear under heavy loads at high speed.

8. *Fatigue Life* . . . ArmaSteel has good resistance to fatigue, giving maximum endurance and long life.

As countless and varied applications have proven, ArmaSteel is an outstanding engineering material. For information on how your product can benefit from this modern casting metal, write for our "ArmaSteel" catalog.

ARMASTEEL® from the standpoint of machinability



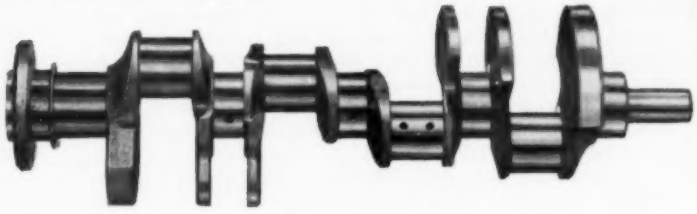
ArmaSteel small horsepower engine crankshafts provide good damping qualities and modest cost due to excellent machinability.



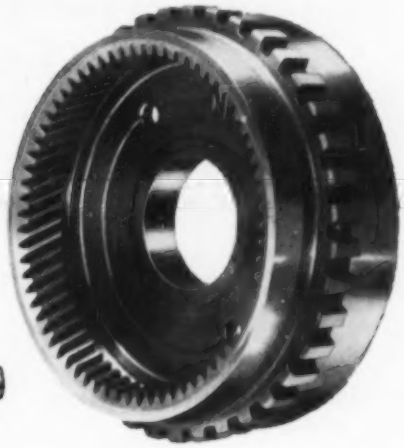
ArmaSteel's adaptability to localized hardening pays off especially well on these automotive rocker arms.



Universal joint yokes of ArmaSteel stand up under severe stresses to same extent as former SAE 1145 or 1151 forgings.



Pontiac's conversion to ArmaSteel Crankshafts doubled cutter life and speeded up by 50% the grinding of main journals.

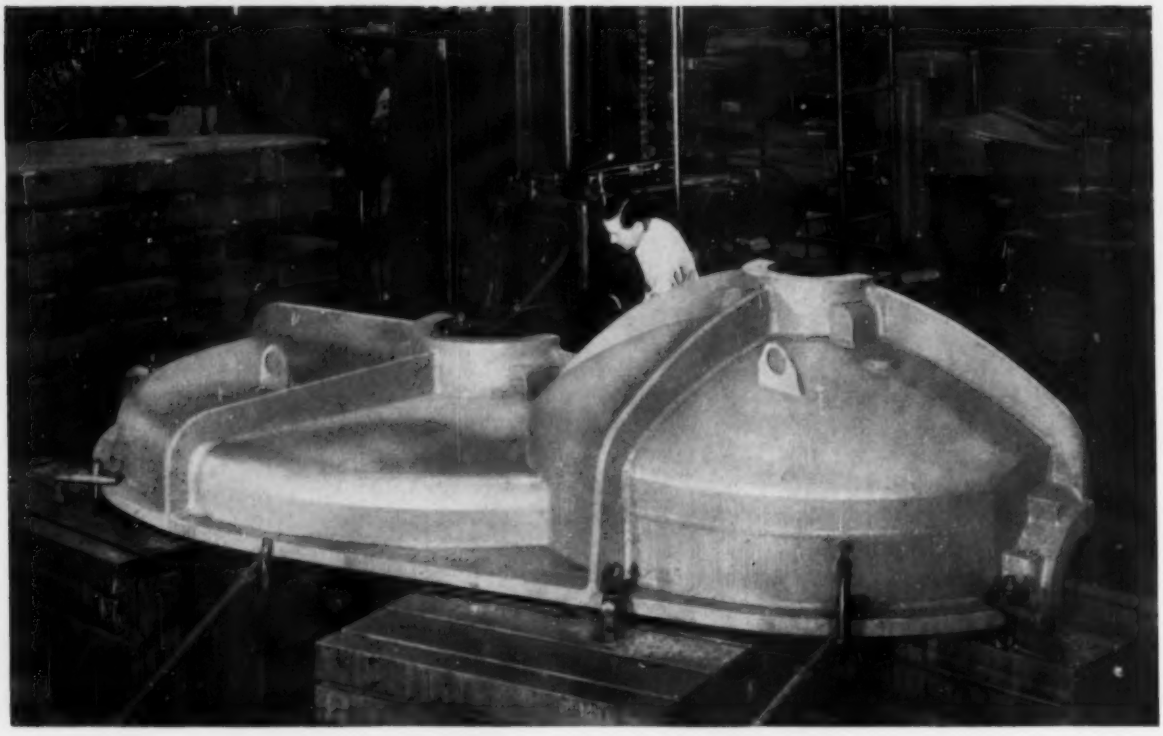


Because of its excellent wear resistance, oil-quenched and tempered ArmaSteel with a Brinell of 241 to 269 has replaced an SAE steel forging for this automotive reverse internal gear.

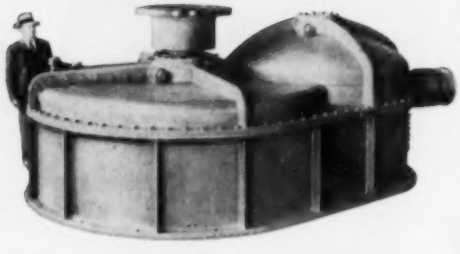
CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 19

STEEL-WELD FABRICATION . . .



PRECISION WELDMENTS Fabricated and Machined to Specification!



FABRICATED, MACHINED and ASSEMBLED IN THE MAHON PLANT

The weldment illustrated above is one of two similar parts of a gear housing for a large speed reducer. The craftsmanship which is plainly evident in this piece is typical of Mahon precision in the production of thousands of Steel-Weld Fabricated parts and assemblies produced year after year for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment.

When your design calls for weldments of any kind, you, too, will want to discuss your requirements with Mahon engineers; because, in the Mahon Company you will find a unique source for weldments or welded steel in any form . . . a fully responsible source with a long and enviable performance record, and unusual facilities for design engineering, fabricating, machining and assembling.

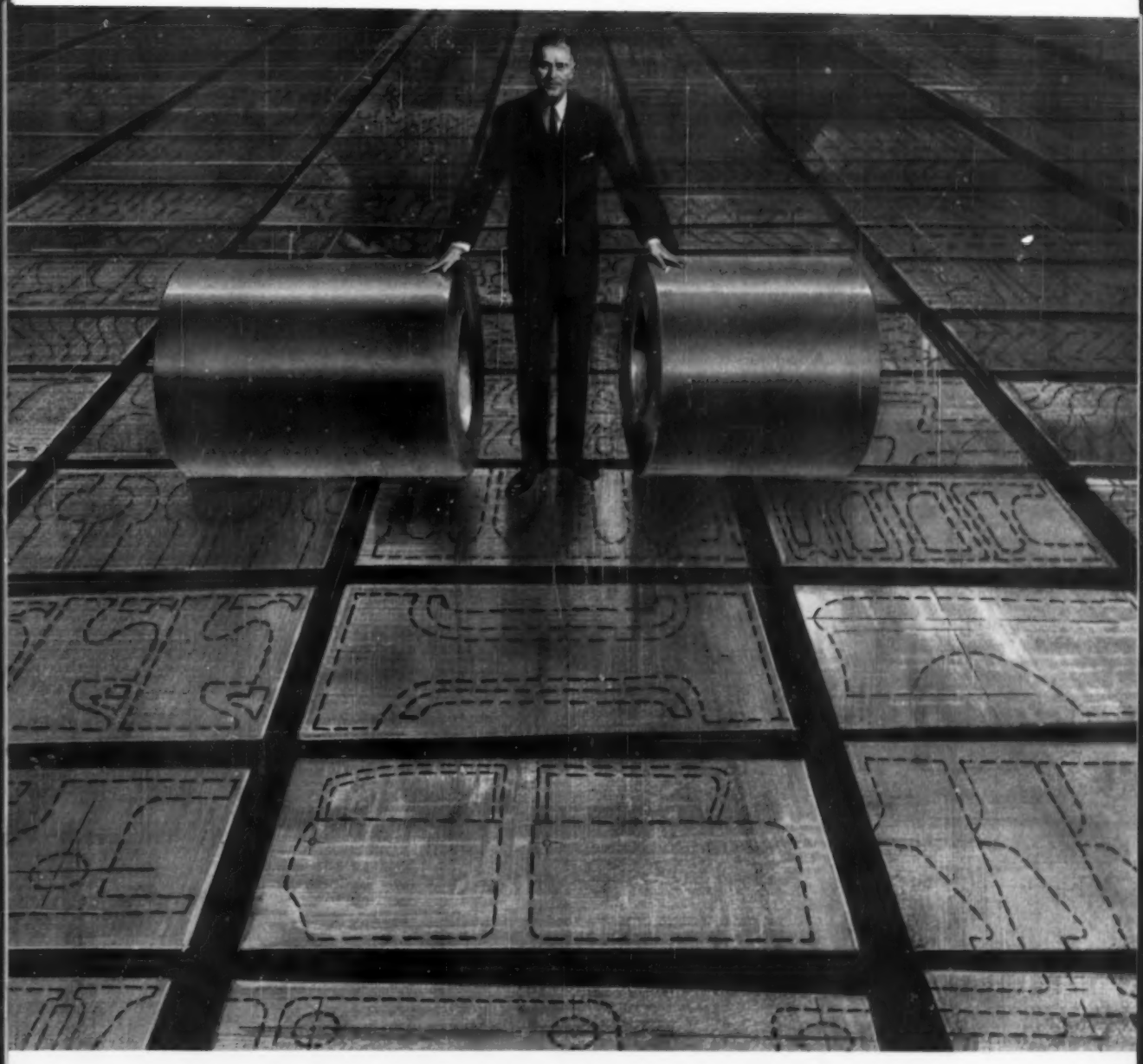
See Sweet's Product Design File for information, or have a Mahon sales engineer call at your convenience.

THE R. C. MAHON COMPANY • Detroit 34, Michigan

SALES-ENGINEERING OFFICES in DETROIT, NEW YORK and CHICAGO

Use WELDED STEEL for 100% Predictability and Greater Strength with Reduced Weight!

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For the production of ferrous and non-ferrous forgings in drop hammers, forging presses, and forging machines, we supply five types of pre-hardened, ready-to-use die blocks, inserts, and tools in SPECIAL MACHINING QUALITY that is commercially machinable *as hard as 477 BHN* with modern, high-speed or carbon tools.

FX—die blocks, inserts and tools for an unusually wide variety of hot work applications, both ferrous and non-ferrous, where reasonable first cost and large volume production is important.

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Finkl is one of the few heavy forge plants in the United States to operate its own electric melt shop. This modern, fully equipped shop makes possible not only better control of steel quality, but also more precise production planning of all operations. Since each heat is melted and processed to meet a specific order or application, we can give individual attention to the particular requirements of each customer, thus assuring the best forging for your job.

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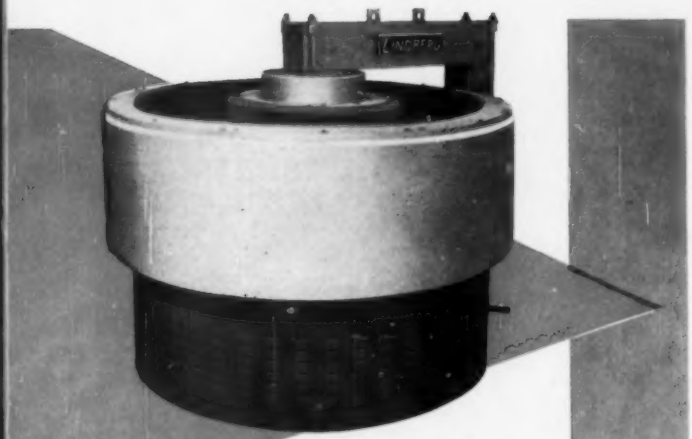
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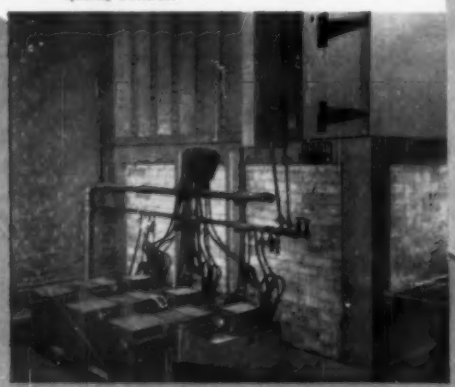
Two good names join . . .

LINDBERG UPTON

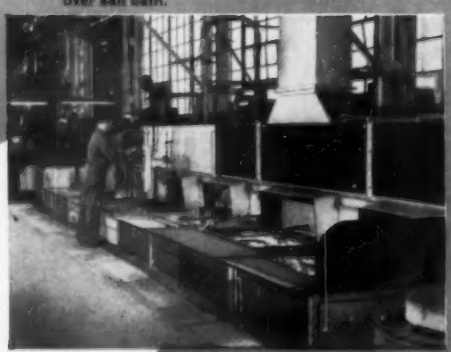
for better service in salt bath furnaces



Lindberg Induct-O-Ring, first electric production salt bath furnace, that can be shut down overnight and regain operating temperature quickly. Rotary action provides positive quality control.



Upton aluminum dip brazing Salt Bath Furnace featuring Continuing Graphite Electrodes. Installation in plant manufacturing industrial heat exchangers. Note insulated chamber over salt bath.



This line of Upton Salt Bath Furnaces, in use in a commercial heat treating plant, handles all types of steel heat treating including high-speed steel tools and parts.

A complete line of high and low temperature salt bath furnaces for any production, pilot plant or laboratory use is now available from Lindberg. This line includes not only Lindberg equipment, but, by joint agreement, the complete line of Upton Salt Bath Furnaces, manufactured by Upton Electric Furnace Company, Roseville, Michigan.

This combination of Lindberg, with its long experience in all types of industrial heating equipment and Upton, leading specialists in salt bath furnaces, will provide industry with more efficient service in the important salt bath furnace field.

Lindberg and Upton engineers and technical staffs are available to assist you in applying salt bath furnace techniques most efficiently to your production processes. Just get in touch with your nearest Lindberg Field Representative (see your local classified phone book) or write us direct. Salt Bath Furnace Division, Lindberg Engineering Company, 2448 West Hubbard Street, Chicago 12, Illinois. Los Angeles plant: 11937 South Regentview Avenue, at Downey, California.

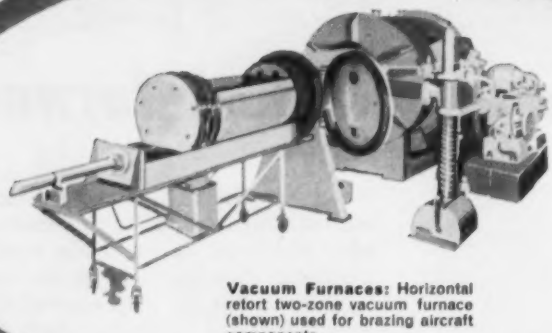
Upton deep submerged electrode Salt Bath Furnace. Available in depths and lengths up to 40 feet or more.



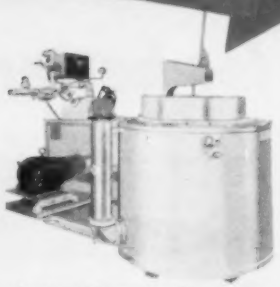
Continuing Graphite Electrodes, an exclusive Upton feature, eliminate bath contamination and provide exceptional savings in electrode costs over conventional, overhanging metal electrodes.

Wherever industry needs heat . . .

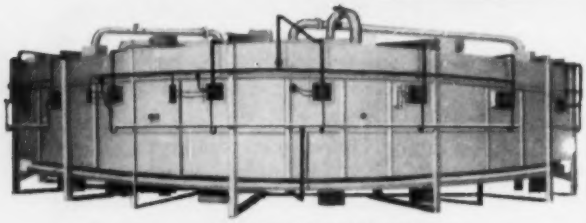
There's *LINDBERG* equipment just right for the specific job



Vacuum Furnaces: Horizontal retort two-zone vacuum furnace (shown) used for brazing aircraft components.



Cyclone Tempering Furnaces: Batch type fuel-fired tempering furnace (shown). Famous in metal treating industry for years.



Rotary Hearth Furnaces: Doughnut type field-installed gas-fired furnace (shown) with capacity of 13,000 lbs. per hour.



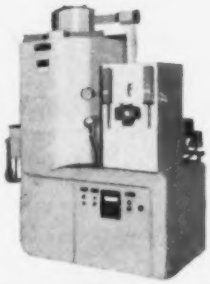
Ceramic Kilns: Completely automated atmosphere controlled kiln with 8 zones of temperature control (shown). Maximum temperature, 2700°F.



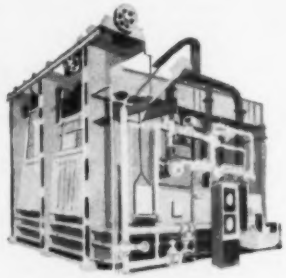
Pilot Plant Equipment: Atmosphere tube unit (shown) for ceramic research and development at temperatures up to 2750° F.



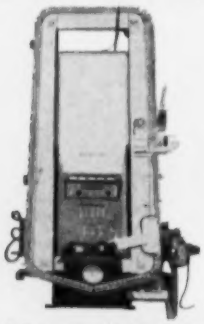
Laboratory Equipment: One-unit box furnace (shown), muffle or for non-oxidizing atmosphere with temperature range to 3000° F.



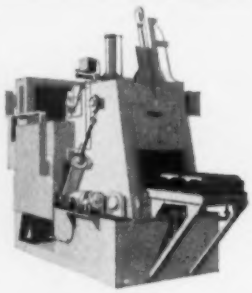
Atmosphere Generators: Hyen generator (shown) for endothermic atmospheres. Generators for all required atmospheres.



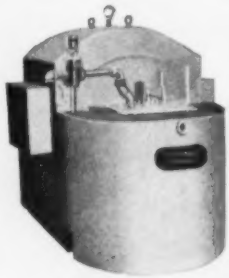
Aluminum Reverberatory Furnaces: Twin-chamber melting and holding furnace (shown) with 45,000 lbs. capacity.



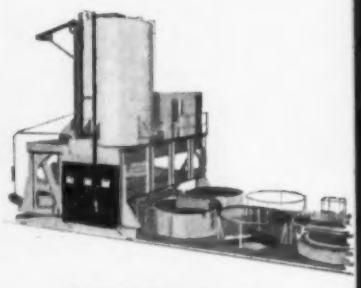
High Frequency Units: Vertically designed, completely automatic "HF" unit (Shown) for aluminizing automotive valves.



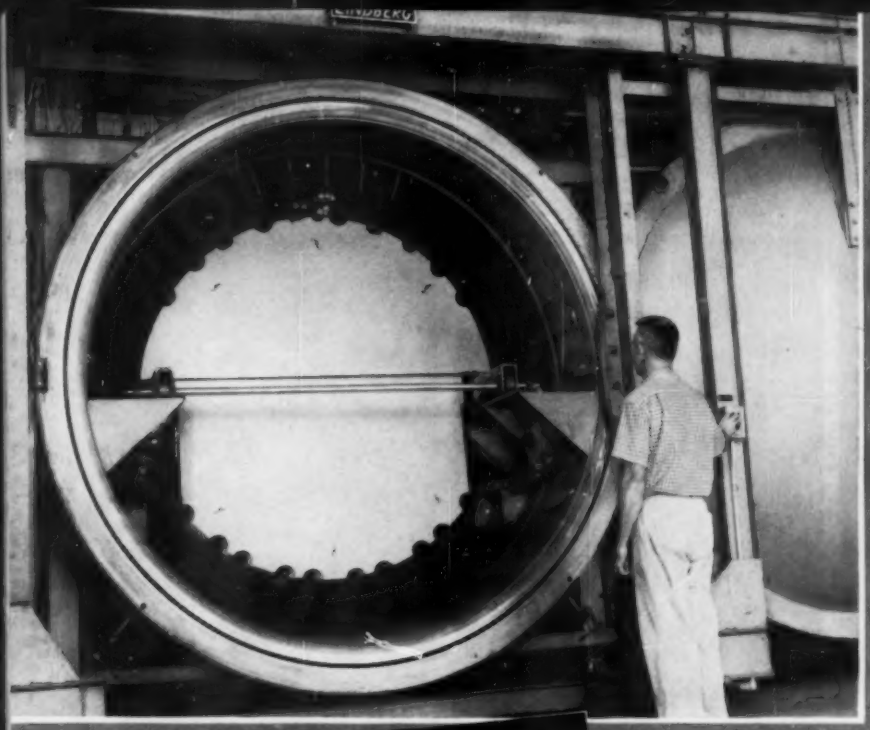
Automatic Carbonitriding Furnaces: Automated integral quench type (shown) with CORRTHERM electric elements.



Melting and Holding Furnaces: Electric resistance furnace (shown) with capacities of 750 lbs. to 1500 lbs.



Gantry Type Furnace: Vertical, controlled-atmosphere, drop bottom, hardening furnace. Complete installation field-installed by Lindberg.

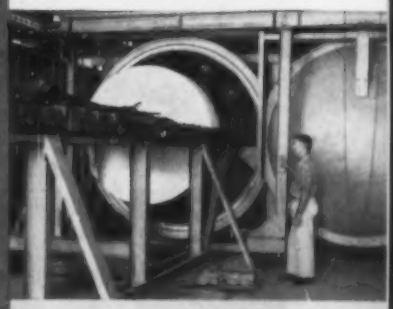


Lindberg-Designed

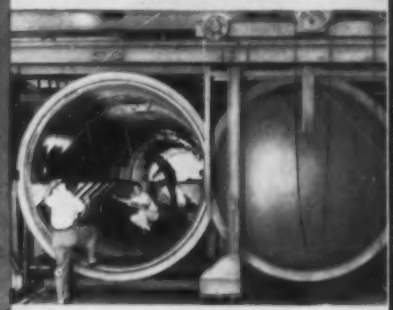
Large Capacity Vacuum Heat Treating Furnace Improves Titanium Quality, Saves Money in Aircraft Manufacture

Here is an outstanding example of Lindberg's ability to apply a basic furnace design to the requirements of a specific job. This vacuum furnace was designed for a leading aircraft manufacturer to heat treat large sheets of titanium. In operation it reduces the hydrogen content of the metal from 500 parts per million to 50 parts per million or less, in a maximum time of 6 hours. And this improvement in quality is achieved with a corresponding reduction in production costs. The furnace has a temperature range up to 2100° F. and operates in a vacuum of less than one millionth of an atmosphere. A unique internal cooling system makes the furnace adaptable for brazing stainless steel honeycombs, a new development in aircraft manufacture.

Lindberg equipment and planning can help you find the answer to any problem of applying heat to industry. We cover the field, heat treating, melting and holding, tempering, brazing, enameling furnaces, ceramic kilns, high frequency units, and are in the ideal position to recommend the equipment most suitable for your needs. This can be factory built or field-installed in your own plant, fuel-fired or electric. Consult your local Lindberg Field Representative (see the classified phone book) or get in touch with us direct. Lindberg Engineering Company, 2448 West Hubbard Street, Chicago 12, Illinois. Los Angeles Plant: 11937 South Regentview Avenue, at Downey, California.



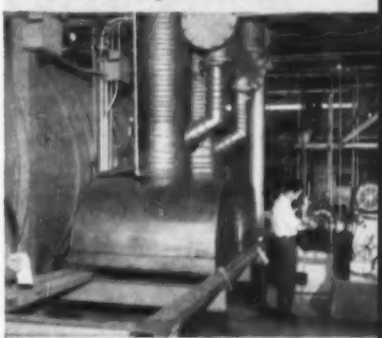
6 feet in diameter, the furnace easily takes large titanium sheets.



Total furnace length is more than 40 feet.



After vacuum cycle, inert gas is introduced into chamber to assist cooling.

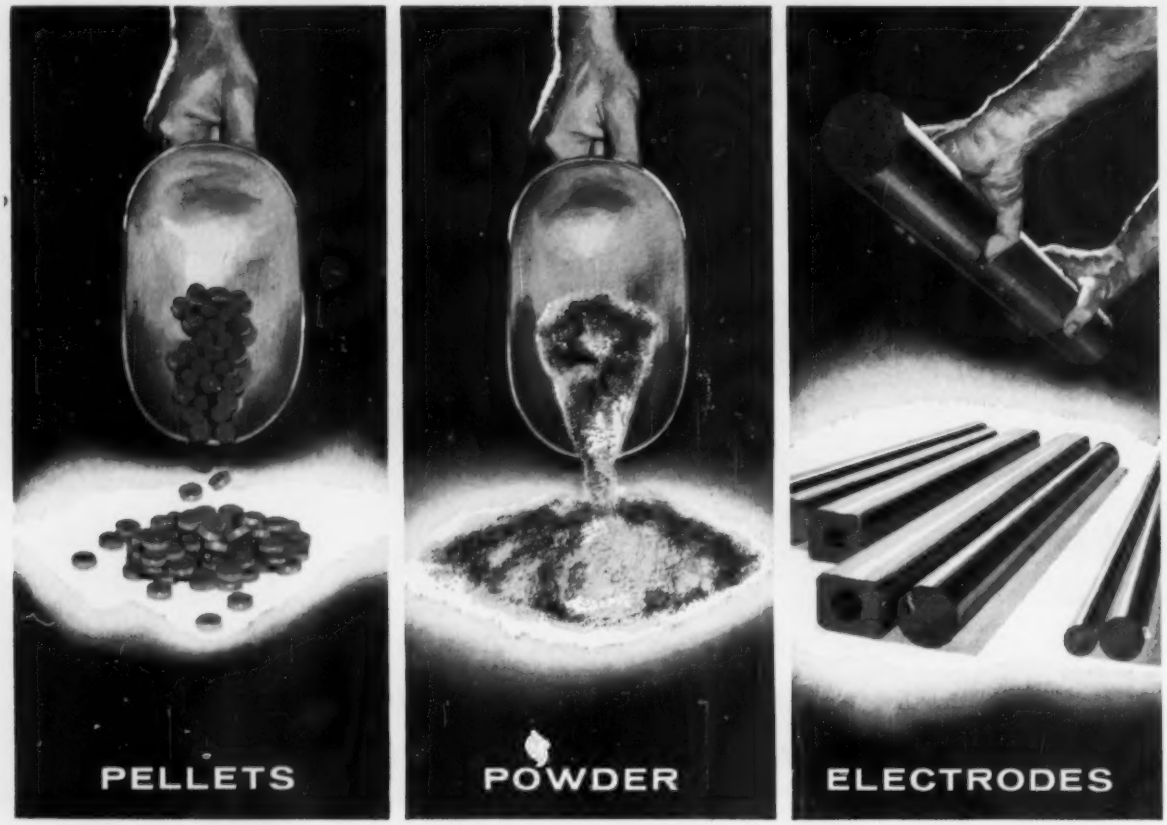


Specially designed pump maintains vacuum of less than one-millionth of an atmosphere.



heat for industry

Sylvania Tungsten and Molybdenum



These valuable forms are producing practical solutions to important high-temperature problems

Powder for slip casting, pellets for vacuum melting, and consumable electrodes for arc castings. These are the important ways in which Sylvania Tungsten and Molybdenum are being used in the development of new and better high-temperature metals.

If any of these forms offer the right solution to your problem, Sylvania can supply the purity and composition you need.

Custom-made raw materials such as these help metals producers meet the precise demands of new high-temperature alloys. They are helping the industry make "Metals of the Future" available today.

You can keep pace with this continuing progress in powder metallurgy by contacting Sylvania's Chemical & Metallurgical Division. We will welcome the opportunity to discuss your high-temperature metal needs with you.

SYLVANIA

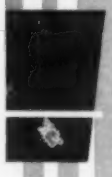
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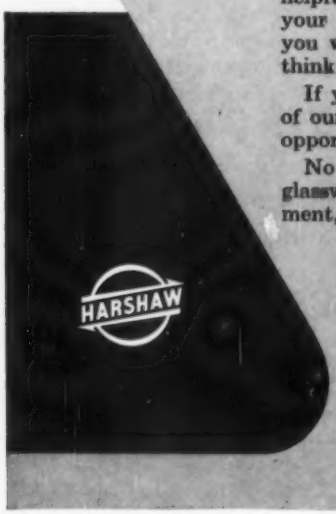
Actually we are the laboratory's SUPER MARKET. The saving in reducing the number of orders placed is tremendous. A recent survey showed that a number of routine customers' orders included as many as 12 to 30 different manufacturers' items. The increased cost of issuing 12 to 30 orders instead of 1 is obviously considerable. Add to that transportation charges from out of the way locations, plus delay in deliveries and the increase in cost cannot be estimated.

We take our job very seriously. Each item is carefully evaluated before being added to our line. Most items are included in our current catalog. As new items become available we attempt to bring them to your attention through space ads and our house organs.

Our branches and sales offices are staffed with personnel trained to be helpful. They have a genuine interest in your problems. In addition we believe you will enjoy dealing with them. We think they're fine people.

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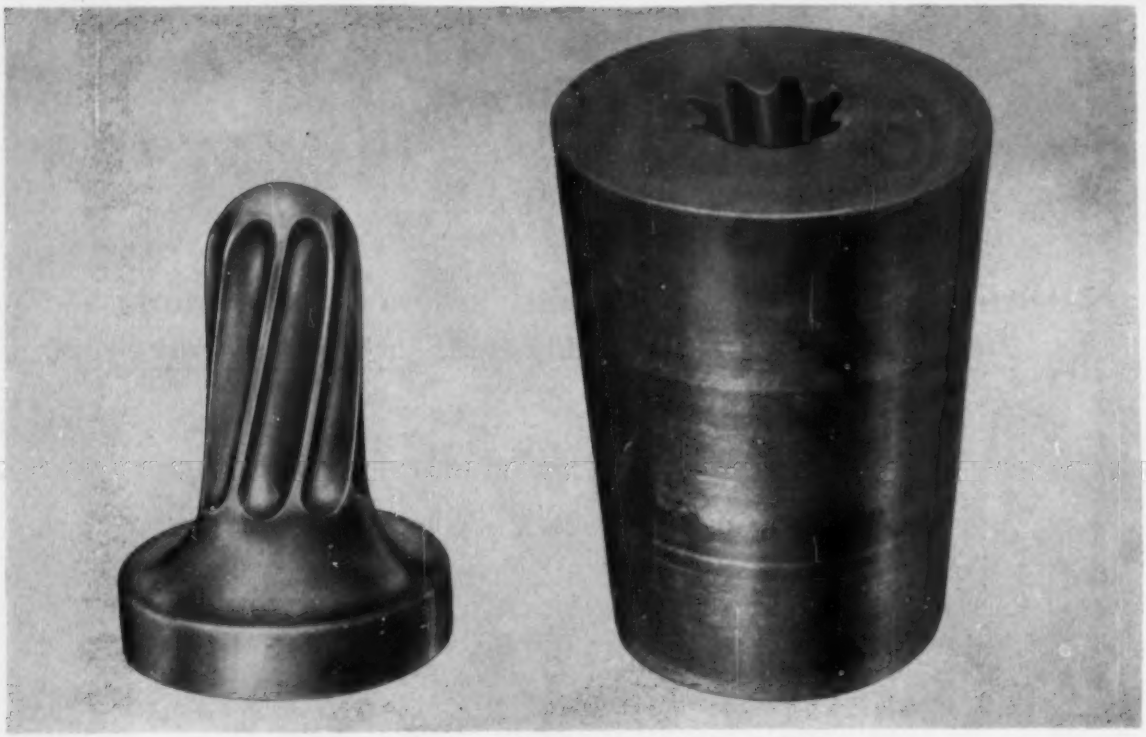
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Cold-hobbed die insert of UHB PREMO, with hob of UHB-711

This Large Plastic Mold Was Cold-Hobbed From UHB PREMO Tool Steel

Unusual Operation Shows PREMO's Excellent Cold-Hobbing Properties

Here's an example of tool steel performance that speaks for itself. The die insert shown above was used in a plastic mold for an appliance component. It was cold-hobbed from Uddeholm's UHB PREMO. Before hobbing, the blank measured 7⅝" in diameter and 8⅛" in height with relief of 5° + 5°. The hobbed cavity measured 2¾" diameter across grooves and 5" overall hobbing depth, with 81° mean helix angle of splines. The size and shape of the cavity made hobbing questionable. With UHB PREMO, however, there was no difficulty.

A 1,000 ton Sack & Kiesselbach hobbing press was used—with 110 tons pressure per sq. in. on the projected hobbing area. The insert was hobbed in four stages and annealed at 1400°F. between hobbings. PREMO's highly uniform grain structure permitted it to "float" away from the cavity—with no trace of checking or unfavorable distortion. Another dependable performer, Uddeholm's Shock Resisting UHB-711, hardened to Rockwell C-60, was used for the hob.

You can expect results like this from all of Uddeholm's fine, Swedish quality tool steels. For a specific tool steel need, analysis alone won't always tell the whole story. *Performance* is the final measure—and in performance Uddeholm tool steels have often *succeeded* where others of similar analysis have failed.

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Tool Steel Stock List No. 13

UHB

UDDEHOLM COMPANY OF AMERICA, INC.

Tool and Die Steels
Cold Rolled Spring Steels

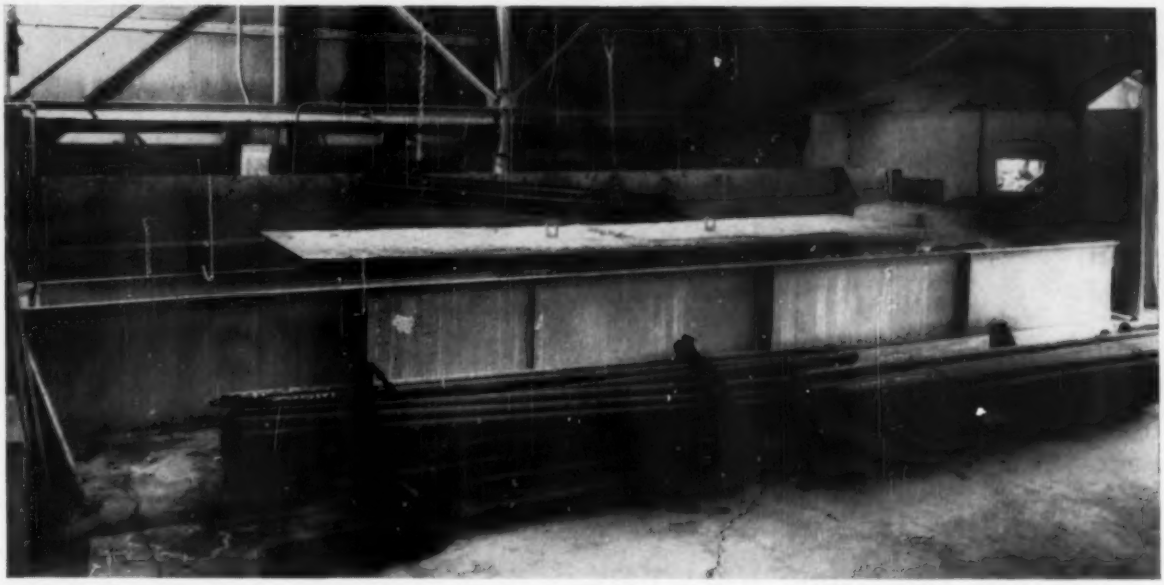
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THE TIMKEN COMPANY CUTS DESCALING TIME



FROM 90 MINUTES TO 30 MINUTES

How Virgo® Descaling Salt gives faster, safer cleaning.

It used to take as much as ninety minutes of straight acid pickling to descale these stainless steel tubes at the Gambrinus Works of The Timken Roller Bearing Company.

Since switching to Virgo Descaling Salt, The Timken Company reports that descaling cycles have been cut down to *one-half* hour with actual acid pickling time reduced to 10 minutes. Equally important too, is the improvement in surface quality.

In the same bath, which handles bundles up to 37 feet in length, the tubes are degreased.

Get these other Virgo advantages in your descaling:

Besides stainless and alloy steels, Virgo Descaling Salt descales titanium and its alloys. You can even handle both types of metal in the same bath.

Virgo Salt reacts only with scale. There's no loss of base metal, no pitting or etching. There's no danger of hydrogen embrittlement.

The Virgo bath is safe and simple to operate, using normal precautions. Bath temperatures run from 800 to 1250°F.

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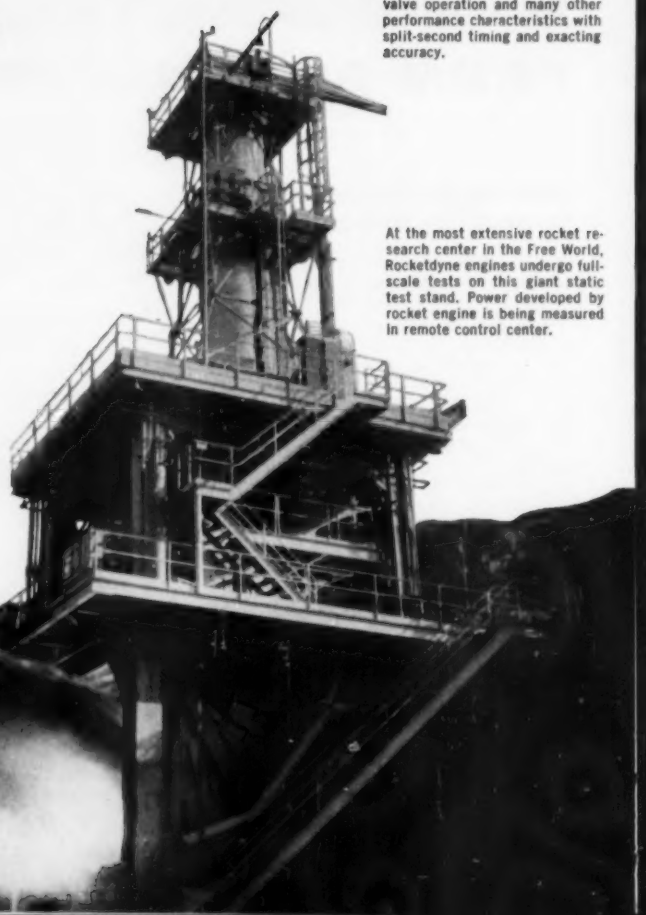
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Tool Steel Topics

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Form tool	172 s.f.m.	.0008"	110 s.f.m.	.0008"
Boring tool	172 s.f.m.	.007"	110 s.f.m.	.007"
Cutoff	172 s.f.m.	.0013"	110 s.f.m.	.0013"
Thread	27 s.f.m.	—	20 s.f.m.	—
Tap	18 s.f.m.	—	12 s.f.m.	—
Production time	35 seconds		49 seconds	

* As demonstrated at National Metal Show, Cleveland, 1958.

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Metal Progress
Volume 75, No. 2 February 1959

Progress in Heating

Buying Industrial Heating Equipment

*By C. F. OLMSTEAD**

TECHNOLOGICAL ADVANCES in the industrial heating equipment industry have been as rapid and revolutionary as in other industries. As a result, a great deal of equipment now in use could be replaced economically. It's hard to know when obsolescence comes, but equipment should not be judged by its attractive new paint job or the fact that it hasn't been entirely depreciated on the books. The real test is how much it costs for labor, fuel, rejections, and all other items that go into the expense of heating parts. If the summation overbalances the cost with new equipment, then new equipment should be considered. It's as simple as that.

Our organization, the Industrial Heating Equipment Assoc., is 30 years old. It was formed to promote better trade practices and business management among its members, and stabilize the industry for the benefit of buyers.

I.H.E.A. members have always been inventive, individualistic and competitive. As evidence of this, hundreds of patents have been issued testifying to their ingenuity and constructive efforts.

Experience is exceptionally important in the training of engineers who design, install and service the equipment. We generally feel that a furnace engineer is not fully qualified until he has at least ten years in the field. Only through such extensive training can furnace engineers and service men gain the knowledge needed to handle the varied types of heating processes.

The buyer of heating equipment will derive his greatest advantage if he invites and encourages the survey and investigative approach. When he permits full leeway to the ingenuity of these specialists and inventors, he will almost certainly end up with the proper equipment for the specific job. Only through full cooperation between buyer and builder can optimum results be achieved. If the bidder is limited to price considerations alone, his initiative is circumscribed by costs; conventional equipment that may be unsatisfactory may result.

The buyer who encourages and shares in the development of new and untried ideas will, usually, surge far ahead of competition; his patience and extra expenses will be rewarded by lower costs, better quality and higher production.

Admittedly, price comparisons are difficult with this suggested method, but it should be obvious that furnace builders do not consider it fair for the buyer to select and combine novel features from several of the bids, rewrite his specifications, and ask the bidders to quote strictly on a price basis. Furnace equipment

*President of Lee Wilson Engineering Co., Cleveland, and President of Industrial Heating Equipment Assoc. This article and three articles which follow were prepared from papers presented at the I.H.E.A. Meeting during the National Metal Congress, Cleveland. A number of companies represented in the Association supplied information for this program.

people do not charge for their engineering service (as do architects) when they bid and they feel their ideas should be considered confidential. To give them away or combine them with those of competition is unethical.

Though furnace prices rise yearly, competition in heating equipment is holding profit levels considerably below the average of other heavy industries. Also, the large amount of free service given during negotiations and after installation, as well as high research and development costs, eats into profits.

Engineering Considerations

We in this organization naturally feel that the equipment we build is safe – if used properly. In group meetings, committees have drawn up codes of practice for general distribution. We urge users to take full advantage of these recommendations for their own benefit and the reputation of the industry.

Wherever possible, we also cooperate in the use of national industrial standards. It has been found impractical, as suggested by some buyers, to standardize on such items as brick, alloy, insulation and the like. To do so would curb development and improvement which I.H.E.A. has been trying to stimulate for the benefit of its members and their customers. The manufacturers of these components are entitled to the same opportunity for constant development as the heating equipment industry; if they are unhampered, improvements can be passed on to the ultimate benefit of the user.

Summary

Let us realize that heating equipment no longer consists of brick-lined steel boxes with simple heating devices. In most plants, heating machines are mechanized and automated; they work to close tolerance of time, temperature and atmosphere – in short, they are precision tools. The design of such furnaces, ovens, gas generators and related equipment is a specialized engineering skill which requires years of training and experience. Research and development in the art progresses so rapidly today that users of this type of equipment should periodically investigate the economics of replacing obsolete equipment with labor and fuel-saving improvements.

Progress in Heating

Improvements in Induction Heating

*By W. E. BENNINGHOFF**

INDUCTION HEATING has come a long way since it was first applied to melting and hardening. This is an industry which combines considerable theory with broad experience, and thousands of research dollars are spent each year to find new ways to reduce processing costs.

From the early hand-feed equipment, we have progressed to completely automatic operations. Parts to be heated are fed into the induction heater, discharged automatically, then conveyed to the next operation. For example, consider surface hardening of the cams, gear and eccentric on an eight-cylinder camshaft. They are automatically loaded in a chute and roll down into an inductor assembly to be heated, quenched, and automatically discharged on a conveyer for the next operation – all in 12 sec.

Figure 1 shows a setup which aluminizes

*Vice-President, Ohio Crankshaft Co., Cleveland, and General Manager, Tocco Div.

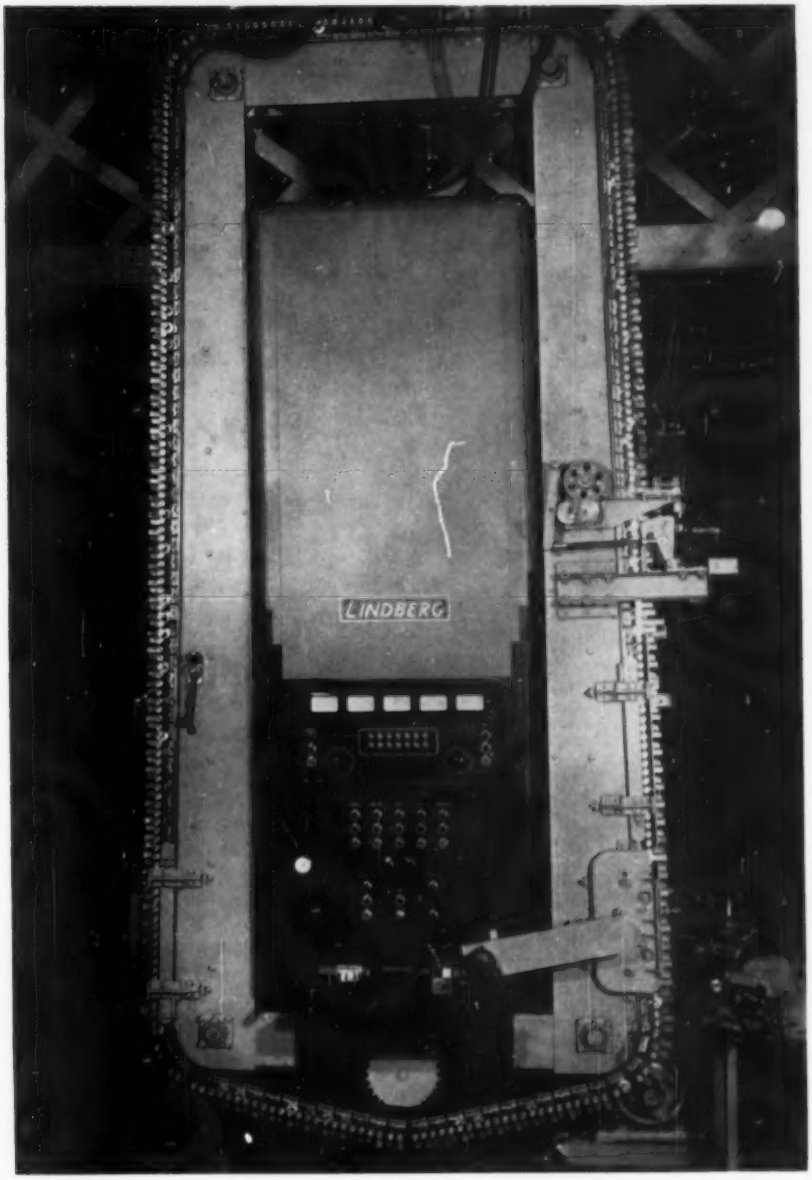


Fig. 1 – Automatic Setup for Aluminizing Valves

valves automatically. The vertical handling system is loaded and unloaded from the shop overhead conveyer. Valves are preheated at one station, then travel to a metallizing gun which sprays them with molten aluminum. A hard heat resistant aluminum alloy is formed by heating at the third station. Production rate is some 3500 valves per hr.

Another example, shown in Fig. 2, is for locally annealing the ends of steering gear shafts made of carburized S.A.E. 4024. In a 12-sec. cycle, parts are automatically loaded onto the conveyer, move to the heating position, and are elevated. Inductors move in over the end sections for annealing; parts are then lowered to be conveyed to the next operation.

Combined Operation

A refinement of automation is the combination of operations on one machine. It is, for instance,

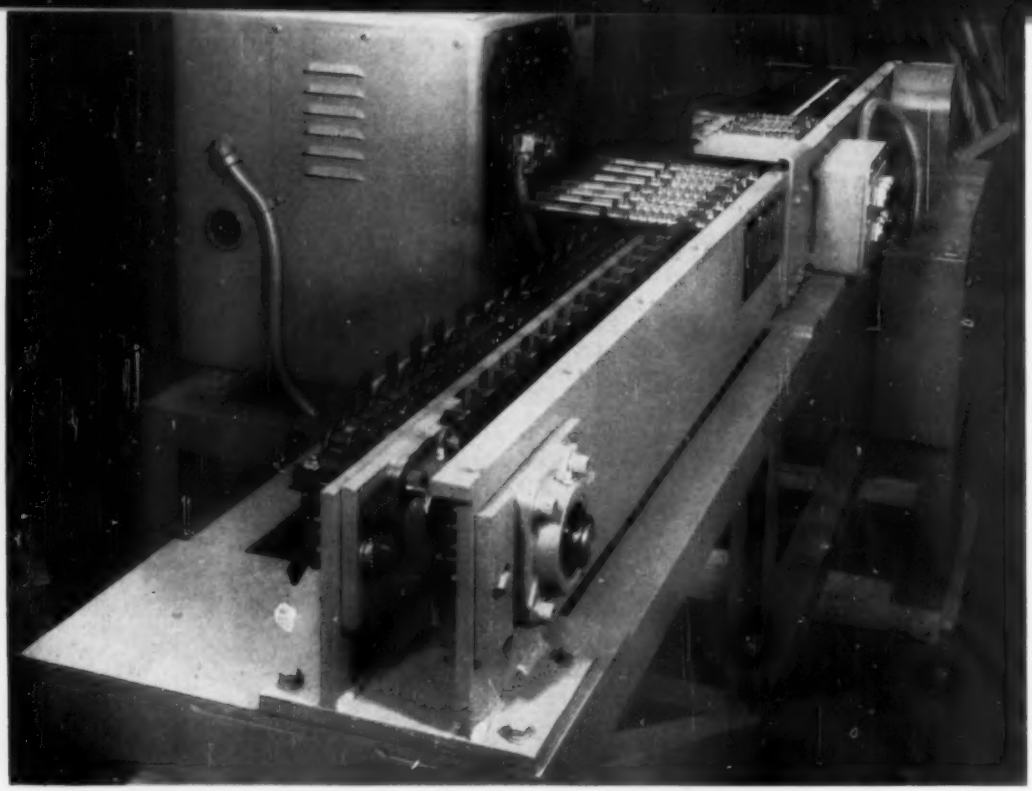


Fig. 2 – Induction Annealing Ends of Steering Gear Shafts Made of Carburized 4024

possible to heat treat a part while it is being machined. An example of this is burnishing and hardening of bearing race cups on an eight-spindle automatic. Previously the cups were:

1. Rough machined in multiple-spindle automatic lathes.
2. Copper plated to prevent carburization of certain areas during heat treatment.
3. Carburized, hardened and tempered.
4. Surface and centerless ground.

Contour grinding the race surface completed the operation.

With induction hardening, all operations (except grinding) have been combined in a new eight-spindle automatic. Roller burnishing of race surfaces prior to hardening has replaced the time-consuming contour grinding. With the three handling operations also eliminated, finished ball races can be made from bar stock and delivered to assembly in a half-day – a cut of 96% in cycle time—because previously at least three weeks was required to schedule a lot of cups from bar stock to assembly.

In this same category is the use of dual frequency in heating billets for forging. A lower frequency is used for preheating, and higher frequency brings the billet to final temperature. When the operator delivers a heated billet to the forging press, he places a cold billet on the conveyer so that the operation is continuous.

Another application of two frequencies is in through heat treating of torsion bars. While a 60-cycle current heats the torsion bar by resistance, the larger end sections are inductively heated with 10,000 cycles. At the end of the heating cycle, parts are quenched.

Atmospheres

Normally the induction heat cycle is so fast there is no time for injurious scale to form and, therefore, no need for atmosphere. However, atmospheres are needed for copper brazing stainless steel, and annealing and heating special alloys and materials.

The machine shown in Fig. 3 butt welds boiler tubes. In applications where welds would be affected by scale, the split box is closed over the weld zone and an atmosphere introduced. An atmosphere is also needed to copper braze stainless steel parts used in aircraft. The operation had previously been done in a furnace; due to the heavy fixturing required to hold the parts in alignment, it was necessary to heat ten times as much material as required for brazing the necessary joints. Even with heavy fixturing, the parts moved; it was not possible to get 100% good brazes. This required sending the parts through the furnace a second time. With induc-

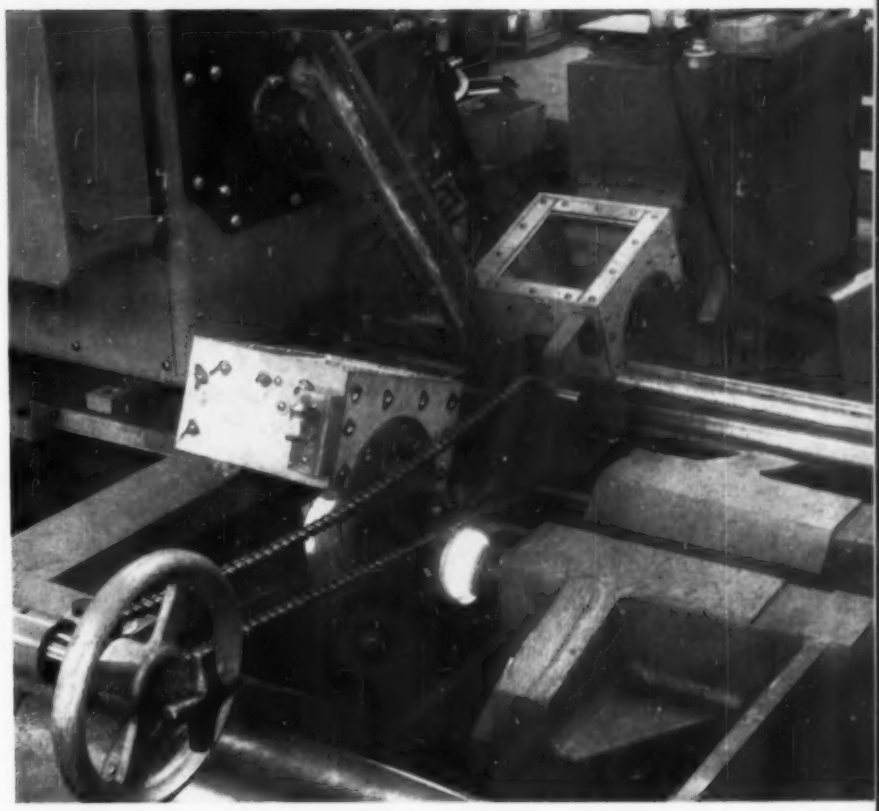


Fig. 3—Equipment for Induction Heating in an Atmosphere. The split box closes on the zone to be butt welded. After the atmosphere is introduced, the pipe is welded

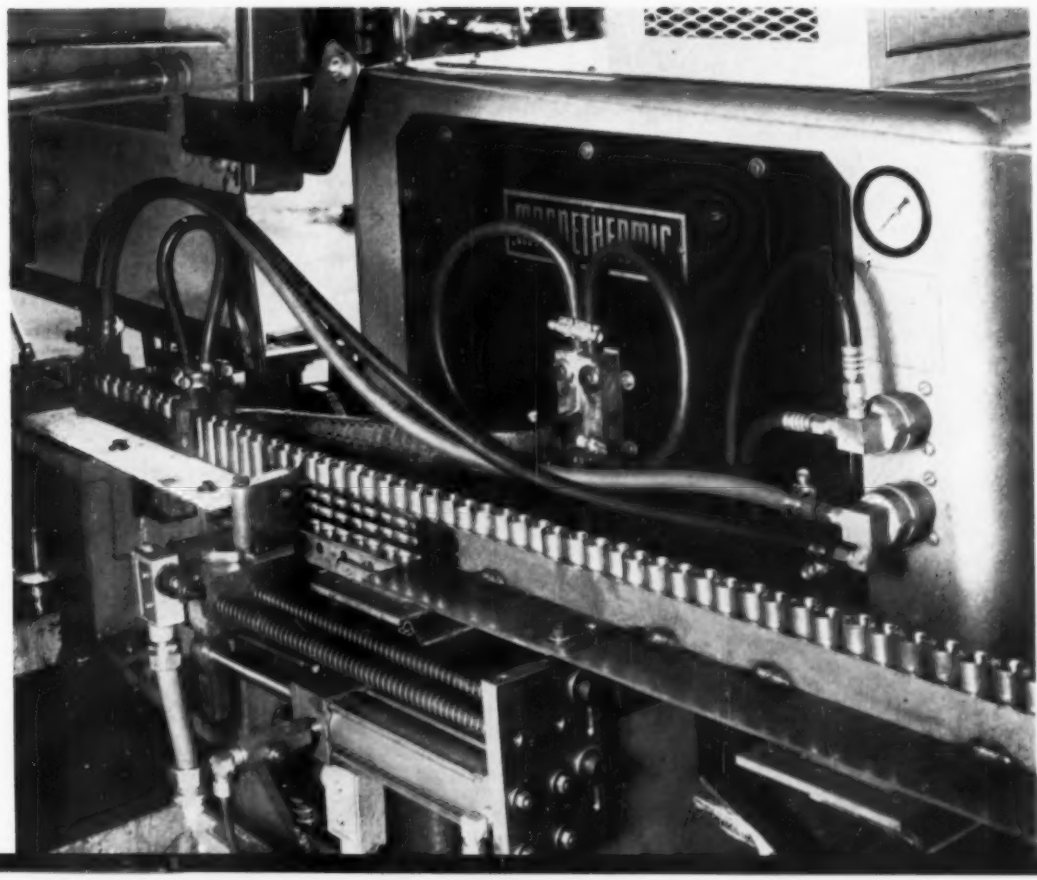


Fig. 4—Induction Equipment for Low-Temperature Heating of Sockets To Be Broached

tion heating producing 100% good brazes, the rate with one unit is five times as great as the rate of five furnaces previously used.

From the use of atmosphere we can progress to the absence of atmosphere — vacuum — and here we find a number of induction heating applications. They include melting, heat treating, crystal growing and zone purification.

Heating at Low Temperatures

Practically all applications mentioned above are in the upper temperature range. However, improvements in induction techniques have enabled heating at low temperatures for baking lacquer on door knobs, stress-relieving, warm heading of bolts, and the like.

Figure 4 illustrates equipment being used for induction heating hex-head wrench sockets to a low temperature for broaching. Warm working produces better metal flow and improves surface finish. Continuous feed to the impact press is entirely automatic. Other low-temperature units can be used for soldering, and for annealing aluminum, copper and bronze door knobs.

The annealing of ball studs, Fig. 5, combines the automatic features previously mentioned with low-temperature heating. Ball studs are loaded, one every second, into the hopper at the upper center of the picture, and fed automatically to fingers which position and carry the stud through the inductor to the left where the threaded ends are annealed to approximately Rockwell C-30. They are then cooled and discharged into the chute at the right.

Recently, fast-acting temperature controls have been developed to monitor the induction heating input. Both combine to control conveyer speed. Controlling billet temperature one to another, end to end, and surface to center is an everyday occurrence. Since billets can be precision controlled individually, the process is fully automated, eliminating man power and speeding up production. Billets up to 12 in. diameter and even larger can be handled in this manner.

Summary

It has often been said that induction heating can be applied to anything that will carry an electric current. This includes molten glass, steel, copper, aluminum, brass, stainless steel, titanium and other materials. The experience of the induction heating manufacturer should be relied upon to select power input, atmosphere, and the fixtures and inductors needed to accomplish the desired results along with desired production rates. This must be done at a low cost with equipment which will operate continuously with a minimum of maintenance.

The induction heating industry has been making improvements since it was first started and is continuing to make improvements. The large amounts being spent on research and development today insure future improvements for not only the metalworking industry but industry as a whole. It is this research by experienced engineers on a broad range of applications which puts our industry in a position to study and solve new requirements.

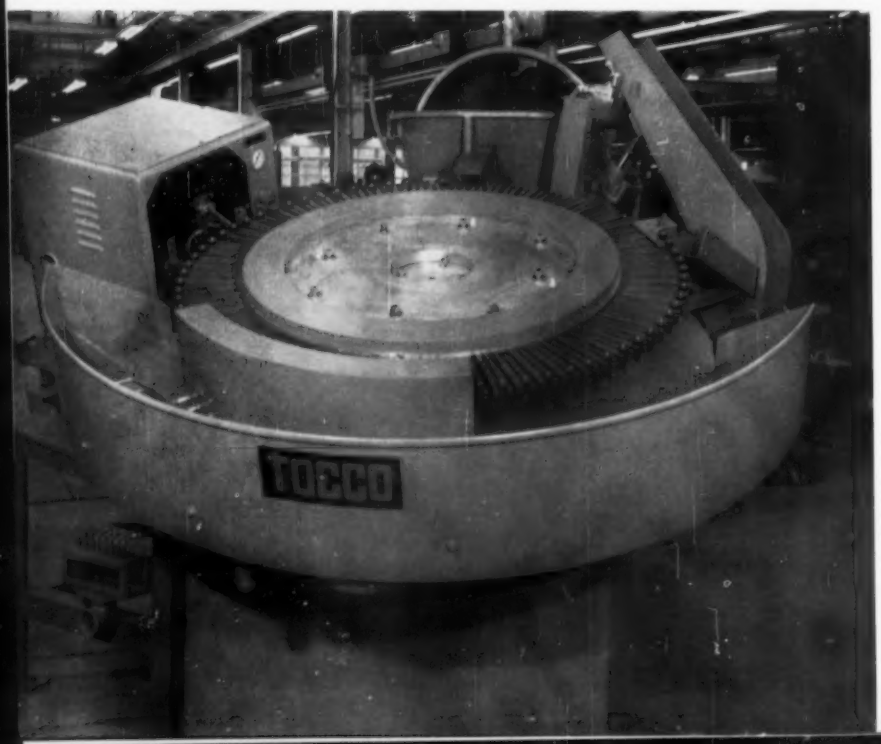


Fig. 5 — Automatic Heating of Ball Studs



Progress in Heating

Vacuum as a Furnace 'Atmosphere'

*By L. W. JOHNSON**

FOR MANY YEARS, the surface of metals being heat treated or melted has been protected by either gases or molten salts, the medium used being selected for specific metallurgical, engineering and economic reasons. Recently, another type of environment – vacuum – has been added to the list. As an "atmosphere" for heat treating and melting certain highly reactive metals, vacuum is extremely useful. In fact, there is no adequate substitute. Titanium, zirconium, molybdenum and tantalum must be melted in vacuum because they react with, or absorb, most gases. These same metals are also annealed in vacuum to prevent contamination by hydrogen or other gases. Among other applications, large steel ingots are vacuum stream degassed to prevent hydrogen embrittlement. Iron and nickel-base superalloys are vacuum melted to meet the stringent demands of jet engines and similar heavy-duty applications. Superior brazes are obtained on some grades of stainless steel when the braze is made in vacuum. Vacuum pumping is often used before critical work is processed in hydrogen or argon furnace atmospheres.

In most instances, vacuum has been employed only because a job had to be done and experience proved that it could not be done any other way. Now vacuum is no longer used as a last resort. Today, many engineers are examining new and existing processes to see if they can't be done better or more cheaply with vacuum. They know now that vacuum is neither a cure-all nor a thing to be feared. Like any other atmosphere, it has certain advantages and disadvantages. Some of the advantages are:

- Nothing is added to the metal, and under proper conditions, undesirable impurities can even be removed.
- No undesirable combustion products are generated during purging, and no explosive mixtures are formed.
- When used only for purging, the undesirable gases can be completely removed before a pure atmosphere is added.
- Better results can frequently be obtained with an active gas (such as hydrogen) if the furnace is evacuated and then filled with a partial pressure of the active gas.
- Frequently, vacuum can be used to hold parts in position during processing.
- Vacuum is less expensive than some gases.
- Metals and alloying materials which cannot be processed in any other atmosphere may be used in vacuum.

Of course, there are disadvantages too:

- In most instances, vacuum is chemically passive. (For instance, hydrogen reduces oxide films much more easily.)
- Desirable alloying materials may be removed. (Zinc and manganese have high vapor pressures.)
- It is difficult to provide a vacuum good enough to compensate for furnace leaks.
- Vacuum pumping is fairly expensive.
- There is no heat transfer by convection.
- The pressure differential between the work zone and atmosphere is substantially higher than is normal with other atmospheres.

The advantages of a vacuum atmosphere are very real and can be measured by the same economic and metallurgical tests used for any other atmosphere. However, its disadvantages as a furnace atmosphere are also very apparent. Two or three of these are genuine process disadvantages; the others merely make it difficult

*Industrial Heating Dept., General Electric Co., Shelbyville, Ind.

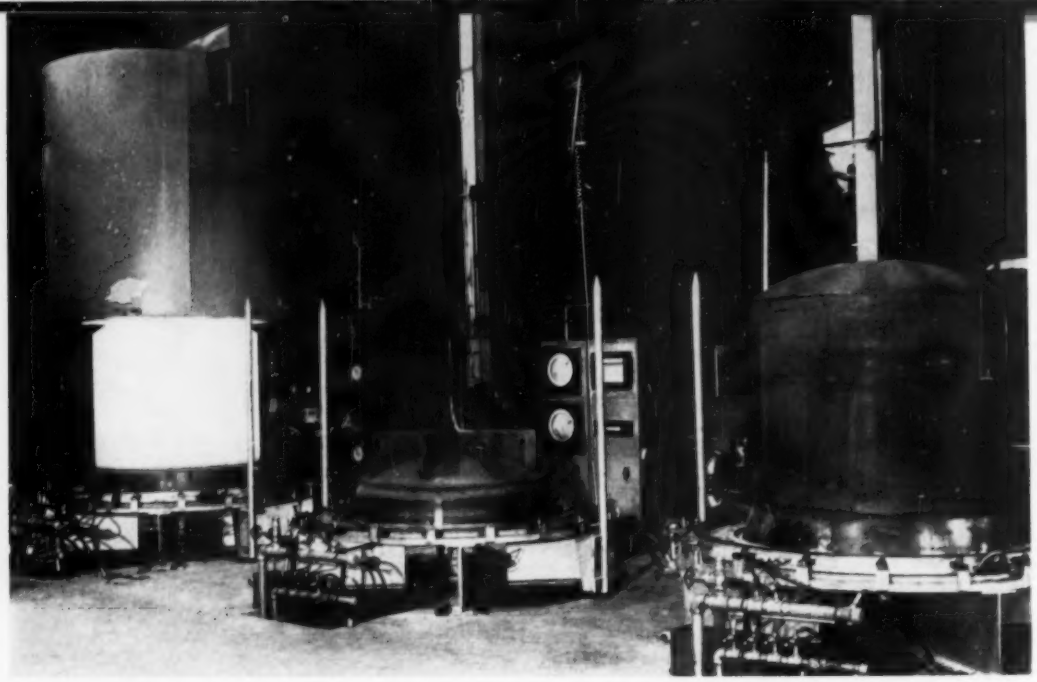


Fig. 1 – Bell-Type Vacuum Furnace at Left Is Being Lifted From a Heated Load. The load at the right is ready to be heated, and the base in the center is ready to be loaded

for furnace manufacturers. Fortunately, they have maintained a continuing development program. Today, an impressive array of furnaces is ready to serve the user, and tomorrow's expanded production needs are certain to be met.

Selection of Vacuum Pump

Obviously, to get a vacuum you need a pump. Three major factors to consider are: (*a*) pump-down time, (*b*) ultimate pressure, and (*c*) pumping speed at operating pressure.

Pump-down time may be the major factor in determining per cent utilization of the furnace. The longer it takes to attain the desired vacuum, the less time the furnace is in operation. This factor is particularly important with large-volume short-cycle units such as brazing furnaces. The ultimate pressure reached by the furnace may determine whether or not it will actually do the job you want done. On the other hand, if you play safe and specify a lower ultimate pressure than is actually required, you may double both the equipment cost and pump-down time. Obviously a laboratory test to determine the actual pressure needed is very desirable. Pumping speed at operating pressure is very important when large volumes of gas are involved. Here again, laboratory tests are valuable. This is particularly true for melting operations because of the tremendous variations in materials.

Five major types of vacuum pumps are available; an almost unlimited range of ratings is offered within these types. Each type and size does a specific job. Most pumping systems require two or more pumps (generally of different types) to obtain the desired pumping characteristics. It is very important, both economically and metallurgically, that your pumping system be selected to give you pumping capacity in the pressure range needed. Pressures seldom used or only passed through briefly should not be considered in specifications.

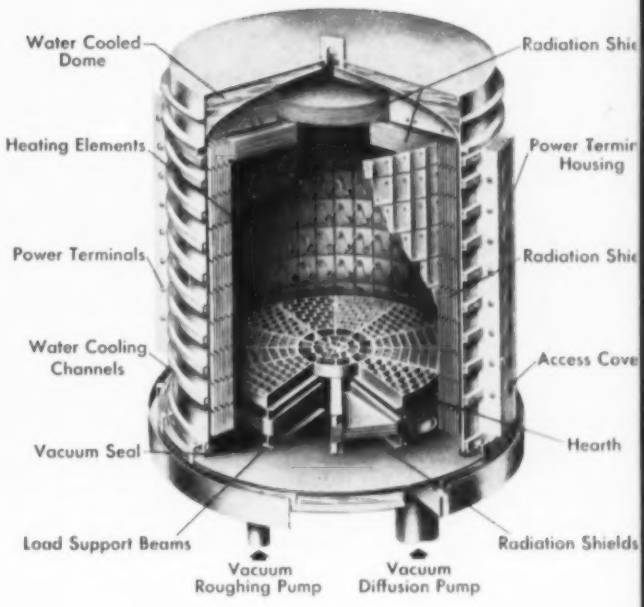
Furnace Types

A vacuum-purge retort furnace is commonly used for furnace brazing of stainless steel honeycomb. Vacuum is used to purge the small quantities of air and water vapor which would be present even after long purging by continuous flow of pure hydrogen or argon. During the actual heating cycle, pure dry hydrogen or argon is normally used for an atmosphere. Since the work is isolated from the heat source, the furnace can be heated with fuel or electricity. In brazing honeycomb with this type of furnace, it is common to evacuate the inside of the honeycomb during brazing. The pressure differential holds the parts together and helps to get a good braze.

Normally, two or more retorts are used with a single furnace so that one load is cooling while another load is heating. An example of this is shown in Fig. 1. The bell-type furnace has just finished heating one load. Another load is ready to heat, and one base is ready to be loaded.

The next type, a double-pumped retort furnace, is used for brazing stainless steel assemblies

Fig. 2 – Cold Wall Vacuum Furnace. Radiation shielding eliminates the need for insulating bricks



and annealing reactive metals. Some stainless grades, particularly those containing titanium, appear to braze better in vacuum than in hydrogen. Also, hydrogen can be reduced in most metals (for example titanium) by holding at a fairly high temperature under very low pressure.

In this furnace, the working area is normally held at 0.1 to 5 microns, while the space between the outer shell and the retort is usually evacuated to about 1 mm. This reduces the pressure differential between the inside and outside of the retort, and also lessens tendency for the retort to collapse at elevated temperatures. Two pumping systems are required. The pump for the space between the retort and the outer shell is relatively small, since it does not have to reach a low ultimate pressure. However, the pump for the retort must have a low ultimate pressure, a fairly high pump-down rate and good capacity at the ultimate pressure because some gases are evolved during the heating cycle. Most of these furnaces can also be used in vacuum-purge atmosphere operations.

Figure 2 illustrates a radiation shield or cold wall furnace. Designed primarily for high-temperature work in vacuum, it eliminates insulating brick and hot retorts. Brick absorbs gases and water vapor when the furnace is open, and these impurities are very difficult to remove. Further, at higher temperatures and low pressures, most brick will break down and release oxygen. Even though metal retorts are used as high as 2300° F., they have a short life.

High-temperature metal radiation shields make the cold retort furnace possible. In vacuum it is fairly efficient because there is no convection heat transfer. However, the outer walls must be water cooled. This furnace (Fig. 2) has two pumping systems: one for initial evacuation to around 1 mm. and the other to reduce and maintain pressure around 0.1 micron.

Melting Equipment

Since the August 1958 issue of *Metal Progress* contained a fairly comprehensive discussion of vacuum melting, this subject will only be reviewed briefly. First, vacuum stream degassing equipment is used primarily to remove hydrogen from conventionally melted steel. Ingots from 10,000 to 200,000 lb. are degassed with high-capacity vacuum pumps of the steam-ejector type. There are several of these units in operation in the United States. In vacuum induction melting, the charge is heated in a ceramic crucible by induced electrical currents. After melting, degassing and alloying, the metal is poured into molds located in the vacuum chamber. Many of these furnaces are equipped with "locks" so they can be charged and molds replaced without breaking the vacuum. The largest of these furnaces can pour 5000 lb. of metal in a single heat. Though these furnaces are ideal for special alloys of iron and nickel, the nonmetallic crucible makes them practically useless for reactive metals.

The most popular vacuum melting method is the consumable-electrode process. The metal to be melted is formed into an electrode, and arc melted into a water cooled copper crucible. This process is very similar to arc welding on a gigantic scale. Ingots produced by this method range in weight from 1 to 25,000 lb., and from 1 to 30 in. in diameter. First used in commercial production of titanium, zirconium and molybdenum, this equipment has been moving into the special steel field and producing some excellent materials.

The vacuum furnaces described are only a few of the many in operation today. Most of them are fairly complex and require careful design, manufacture and coordination of components. However, many equipment manufacturers are capable of supplying complete heat processing systems to do any specific job in the vacuum field. They are at your service.

Progress in Heating

Austempering and Martempering Practices

*By A. F. HOLDEN**

AUSTEMPERING, martempering and allied isothermal heat treatments have been studied in the laboratory for years. Furnace builders have managed, during the course of this work, to translate experimental findings into production equipment which will give consistent results in heat treated parts. Both oil and salt quenching are practical; the medium employed depends upon the results desired.

To begin with, a description of each of the two processes is needed. In austempering, the parts are quenched in a bath a few degrees above the M_s, held at that temperature until complete transformation to bainite is achieved, and cooled. Martempering is simpler; the parts are quenched to the M_s, held until temperatures are even throughout, and cooled slowly through the martensite range. Each method minimizes the distortion and cracking that rapid quenching may cause. In addition, austempering aids ductility, as Table I shows.

As stated before, either oil or salt can be used for quenching. Each system, of course, has its advantages and disadvantages. For example, hot salt requires no atmosphere; but if oil is used without atmosphere, it will break down faster and its life will be shorter. Gases over the oil on larger units can be filtered (to remove oil vapor), cleaned, and returned to the system. This helps reduce the amount of atmosphere required from the generators.

Some of the advantages mentioned for hot oil quenching are listed below:

- It can be used at a lower temperature than is practical for salt. This increases utility of the quench bath; a greater variety of steels can be handled.
- Quench tank can be designed to handle hot oil

*President, A. F. Holden Co., Detroit.

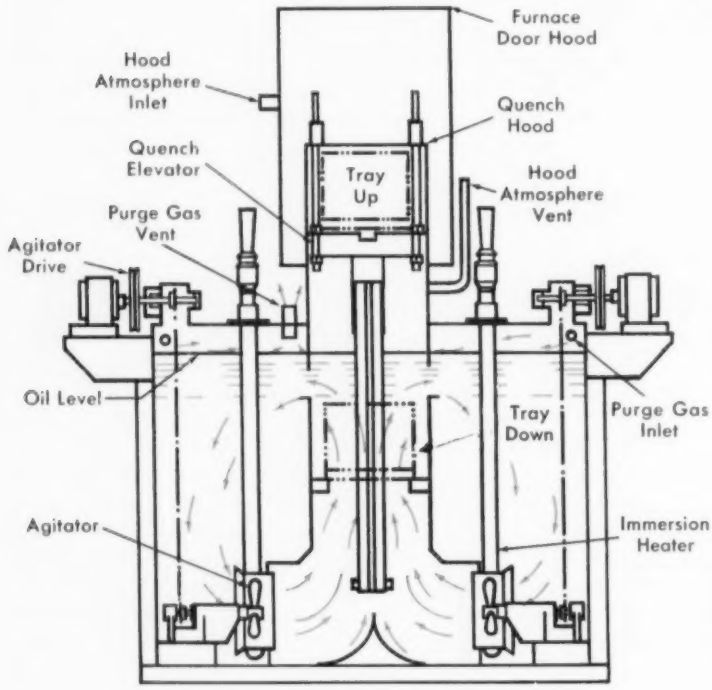


Fig. 1 – Diagram of Enclosed Quench Tank. This protects the oil from oxidation; lower oil replacement costs are the result. This is a direct flow system

Table I – Comparison of Heat Treatments for 1085 Steel

Treatment	Tensile	Yield	Elongation	Bend Test	Tensile-Yield Ratio
Oil quenched	190,800 psi.	160,500 psi.	9.0%	132°	84.3%
Austempered	190,800	146,600	10.0	167	77.8
Oil quenched	219,800	184,200	7.3	101	84.2
Austempered	208,800	163,900	9.0	164	78.8
Oil quenched	250,600	213,300	6.3	77	85.2
Austempered	259,000	213,300	7.3	117	82.3
Oil quenched	111,200	86,000	18.5	—	—
Martempered	110,100	88,000	19.5	—	—

or conventional quenching oil (cool).

- Quenched parts are relatively easy to clean.
- Quenchant does not corrode steel or equipment.
- There is no danger of explosion, and it's relatively easy to protect from fire hazards. Martempering oils have a high flash point.

These points set forth the principal advantages of hot oil over hot salt; however, it should be noted that a closed system (such as shown in Fig. 1) is usually necessary. Inasmuch as no atmosphere is needed for hot salt, the work can be quenched from almost any sort of furnace or salt bath. Circulating systems are generally used for both oil and salt. The quench units should have sufficient volume with propellor speed fast enough to assure uniform cooling rates throughout the entire load.

Table II – Distortion and Growth Data

Parts	Standard Quench (Oil at 140° F.)	Marquench (Oil at 300° F.)
Shifter rails		
10 in. long, camber	0.012 to 0.016 in.	0.003 in. max.
14 in. long, camber	0.018 to 0.026	0.005 in. max.
Couplings, 2¾ in. long, 1.56 in. O.D., 0.750 in. I.D.		
Change in I.D.	0.006 to 0.009*	0.001 to 0.002†
Out of round	0.003 to 0.005	0.0005 in.

*Growth †Shrinkage

Water Additions

Cooling rates can be readily controlled in salt baths by adding water, as Fig. 2 illustrates. No explosion hazards are created, and the additions needed can be easily determined. However, the old saying "oil and water do not mix" definitely applies to oil quenching baths. Water is *not* a suitable addition. Quenching is often impaired, and soft spots are likely to occur on the parts.

Further control of the cooling rate can be attained by reversing the flow in the system. Higher speeds and reversed flows give faster quenching rates. (Incidentally, when the flow is "reversed", the quenchant flows through the load from the top; Fig. 1 illustrates direct flow.)

The furnaces used for austempering and martempering come in many shapes and sizes, depending on the job to be done. Many steels, including 4130, 8630, 4640, 5140 and 4340, can be marquenched to full hardness in 300 to 350° F. oil or salt. Successful results depend, to a great degree, on the pumping system employed. If the pumps are large enough, uniform properties in heat treated parts can be virtually guaranteed. This uniformity, plus the lessened distortion and cracking inherent in the two processes, are good reasons for austempering and martempering.

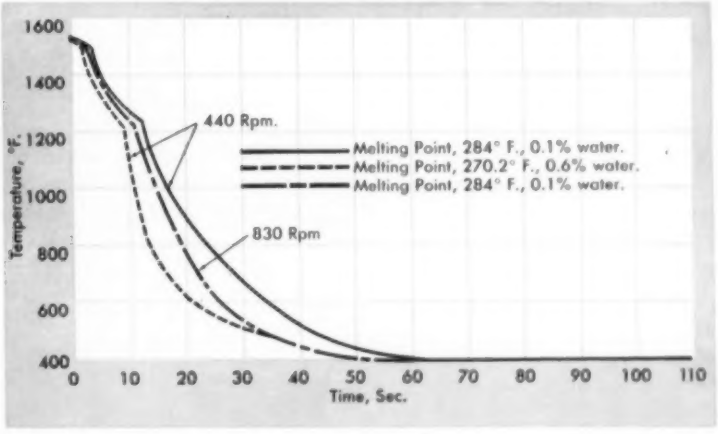
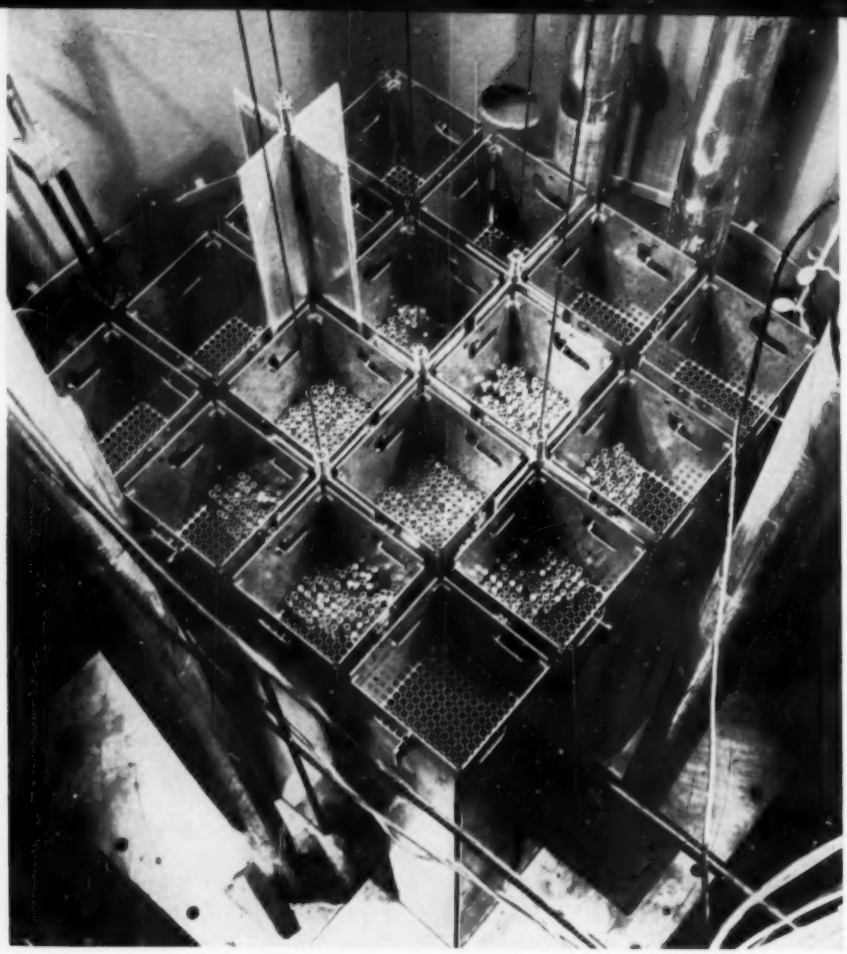


Fig. 2 – Effect of Water Additions on Salt Quenching Rates. Adding water and reversing flow help to increase cooling rates



This Test Core Is Being Used to Establish the Best Design for Nuclear Propulsion System of NS Savannah. Each of the fuel cans contains stainless steel rods that have been filled with slightly enriched uranium oxide. (Courtesy Babcock & Wilcox Co.)

An Economic Appraisal of Stainless Steel and Zirconium in Nuclear Power Reactors

*By MANSON BENEDICT**

Zirconium (as Zircaloy) instead of stainless steel as structural material, fuel cladding or fuel diluent in nuclear reactors enables savings to be made through the use of uranium of lower enrichment or reduction in the critical mass. This study included five power-producing thermal reactors chosen to span the entire range of fuel enrichment.
(W11p, 17-57; SS, Zr-b)

Table I – Break-Even Price for Zircaloy in Reactors

	NPD Reactor	Sodium-Graphite Reactor (SGR)	Yankee Atomic Electric Reactor (YAER)		Merchant Ship Reactor (MSR)		G.E. Developmental Boiling Water Reactor
Developed by:	A.E.C. of Canada and Canadian G.E.	Atomics International	Westinghouse		Babcock & Wilcox		General Electric
Owner:	Hydroelectric Power Commission of Ont.	Consumers Public Power of Nebraska	Yankee Atomic Electric Co.		Maritime Commission and A.E.C.		G.E. and Pacific Gas & Electric
Megawatts, electric	20	75	134		—		5
thermal	80	250	480		85		20
Load factor	0.8	0.8	0.8		0.8	0.4	0.6
Materials now specified							
fuel cladding	Zr	SS	SS		SS	SS	SS
permanent parts	Zr	Zr	—		SS	SS	—
Lb. of uranium in fuel	14,140	53,800	53,500		19,400	19,400	43
% U^{235} in fuel	0.71	1.8	2.6		3.64	3.64	93
MWD per ton*	4000	3500	8240		8113	8113	—
Burn-up fraction	0.0043	0.0037	0.0088		0.0087	0.0087	0.20
Reactivity lifetime, years	0.98	1.17	1.43		2.86	5.72	0.99 (SS) 0.57 (Zr)
Fuel cladding							
Form (tubing)	0.567 in. O.D.	0.495 in. O.D.	0.305 in. I.D.		0.448 in. I.D.		sheet
Thickness, mils, SS,	30	10	15	15	26.5	26.5	5
Thickness, mils, Zr,	30	10	15	30	38	38	5
Zr break-even price, $/lb.	104	57	51	25	44	57	10
Permanent parts†							
Zr break-even price, $/lb.	842	592	—	—	141	109	—

*Megawatt-days per ton. †Equal thicknesses and volumes assumed for SS (stainless steel) and Zr (Zircaloy).

In most of the nuclear reactors being designed today for commercial power production, it is technically feasible to use either stainless steel or a zirconium-base alloy, such as Zircaloy, as structural material, fuel cladding or fuel diluent. When used within the neutron flux of the reactor, the low neutron-absorbing cross section of zirconium gives it economic advantages over stainless – uranium of lower enrichment may be employed, and the critical mass of uranium may be reduced. On the other hand, zirconium alloys cost more than stainless steel. The economic incentive to use zirconium instead of stainless then will depend on the relative magnitudes of the resulting savings in fuel costs compared with its higher material cost.

To assist reactor designers in determining when it is advantageous to consider zirconium as fuel cladding or structural material in nuclear reactors, Columbia-National Corp. made a study of the relative economics of using Zircaloy or stainless in five representative power-producing thermal reactors. This report summarizes the results of this study.

Table I lists the five reactors we investigated. They were chosen to cover the entire range of U^{235} enrichment in fuel – from natural uranium (0.71% U^{235}), in the NPD Reactor, to fully enriched U^{235} (93% U^{235}), in the General Electric Developmental Boiling Water Reactor. It will be evident later that this is one of the most important factors influencing the break-even price of Zircaloy.

NPD Reactor

Under development by Atomic Energy of Canada, Ltd., and Canadian General Electric Co., this will be the first power reactor using natural uranium as fuel to go into operation in the Western hemisphere (Fig. 1). For successful operation on natural uranium, it must use materials with low neutron absorption. Pressurized heavy water has been specified as coolant and moderator. Zircaloy has been selected as struc-

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tural material both for permanent parts of the reactor and for fuel cladding (which must be replaced about once a year with each new charge of fuel). The mechanical design of this reactor was recently modified so that individual cooling tubes now take the principal pressure stresses in the reactor instead of the external pressure vessel being subjected to these stresses. The break-even price study has been based on the pressure-vessel design instead of the pressure-tube design because detailed information on the latter design was not available, but this would not have much effect on the break-even price of Zircaloy.

Sodium-Graphite Reactor

This design is being developed by Atomics International, under contract with A.E.C. for Consumers Public Power District of Nebraska. The reactor is cooled by molten sodium, moderated by graphite, and fueled with uranium slightly enriched in U^{235}. A large amount of Zircaloy is specified in permanent cladding for graphite moderator blocks (Fig. 2). A smaller amount of stainless steel will be used in cladding for fuel elements, which are to be replaced at intervals of 1.2 years. The original design called for uranium fuel containing 1.8% U^{235}. The most recent design, which calls for a somewhat richer fuel (2.5%), was not used in this study. The richer uranium fuel would reduce the break-even price somewhat.

Yankee Atomic Electric Reactor

This design, being handled by Westinghouse for Yankee Atomic Electric Co., is cooled and moderated by pressurized light water and uses stainless steel as cladding for fuel elements, to be replaced at intervals of 1.4 years. Fuel consists of uranium oxide pellets enriched to 2.6% in U^{235} (Fig. 3).

Merchant Ship Reactor

This reactor, under development by Babcock and Wilcox Co. for Maritime Administration and the A.E.C., is also of the pressurized-water type. It uses stainless steel (see photo page 76) both for permanent parts of the reactor core and as cladding for UO_2 fuel elements (to be replaced every 3 to 6 years, depending on the reactor load factor). Fuel for this reactor is to be enriched in U^{235} to 3.64%.

G.E. Boiling Water Reactor

This reactor is being operated by General Electric Co. to get experimental data on the characteristics of a boiling-water reactor system. For fuel, it uses a powder compact of UO_2 and stainless steel, clad with stainless sheet. The uranium is fully enriched (93% U^{235}). This reactor was chosen for this study because complete design information was available and its characteristics are representative of other fully enriched reactors – such as the Army Package Power Reactor, for which complete design information was not available at the time of this present study.

The study showed that the break-even price of Zircaloy ($10 per lb.) was so low that its use would never be economic in this reactor. Hence, the question whether it would really be mechanically feasible to fabricate a powder-compact fuel element from Zircaloy instead of stainless steel does not have to be faced. In all other types of reactors considered in this study the operating conditions are such that it is technically feasible to use Zircaloy or stainless steel interchangeably, both in fuel cladding and in permanent parts of the reactor.

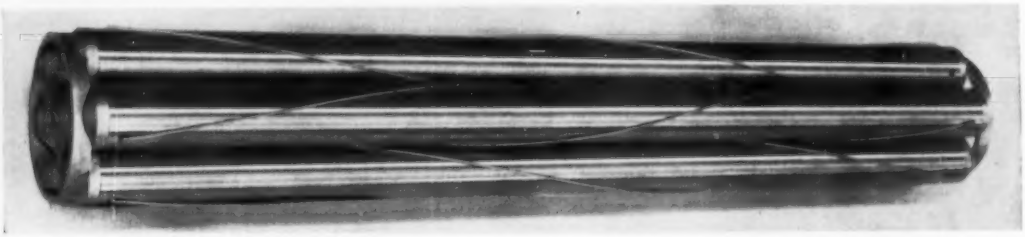


Fig. 1 – An NPD (Atomic Energy of Canada) Fuel Element Consists of a Bundle of Seven Cylindrical Tubes, 19½ In. Long. Tubes are made of a zirconium alloy filled with natural uranium oxide pellets

Comparison of Break-Even Price

The principal factors listed in Table I which affect the break-even price of Zircaloy are: (*a*) the per cent U^{235} in fuel; (*b*) the burn-up fraction; (*c*) the fuel reactivity lifetime; and (*d*) the

relative thicknesses of stainless and Zircaloy used when one material is substituted for the other. By burn-up fraction is meant the fraction of uranium atoms (U^{238} as well as U^{235}) which is converted to fission products by the time the fuel is discharged from the reactor.

The lower part of Table I gives data for the break-even price of Zircaloy under two situations: when used in fuel cladding, to be replaced at the end of each fuel life, and when used in permanent parts of the reactor, which are assumed to last as long as the reactor. As data in Table I show, the break-even price of Zircaloy when used in fuel cladding is much lower than when used in permanent parts of the reactor. This is because one cannot afford to pay as much for Zircaloy when new material must be bought with each charge of fuel as when it need be bought only once in the life of the reactor. The break-even price, both in fuel cladding and in permanent parts, decreases as the per cent of U^{235} in the fuel increases. Thus, other things being equal, the higher the per cent of U^{235} in fuel, the lower the break-even price.

When Zircaloy is used in fuel cladding, the break-even price for the NPD Reactor (it uses natural uranium fuel) is $104 per lb. This is so high that the decision of the Canadians to use Zircaloy in this reactor is amply justified. In the other reactors, using uranium enriched above the natural abundance, the break-even price of Zircaloy in fuel cladding is $57 or less. The present price of Zircaloy tubing of a size suitable for fuel cladding is in the range of $40 to $60 per lb. In the G. E. Developmental Boiling Water Reactor, the break-even price of $10 per lb. is so low that one can conclude that it would never be economical to use Zircaloy for fully enriched reactors.

When Zircaloy is used in permanent parts of the reactor, the break-even price ranges from $842 per lb. in the NPD Reactor to $109 per lb. in the Merchant Ship Reactor. These values are so high that one may conclude that Zircaloy should be used as permanent parts in reactors fueled with slightly enriched uranium, at least up to 4% U^{235}.

Most of the break-even prices given in Table I are based on the substitution of one volume of Zircaloy for one volume of stainless steel. The break-even price is approximately inversely proportional to the volume of Zircaloy substituted for stainless steel. This generalization is illustrated by the two cases for the Yankee Reactor listed in the table: The break-even price drops from $51 per lb. for 15-mil Zircaloy tubing to $25 per lb. for 30-mil tubing.

The first three reactors listed in Table I will be used in large, central-station power plants at

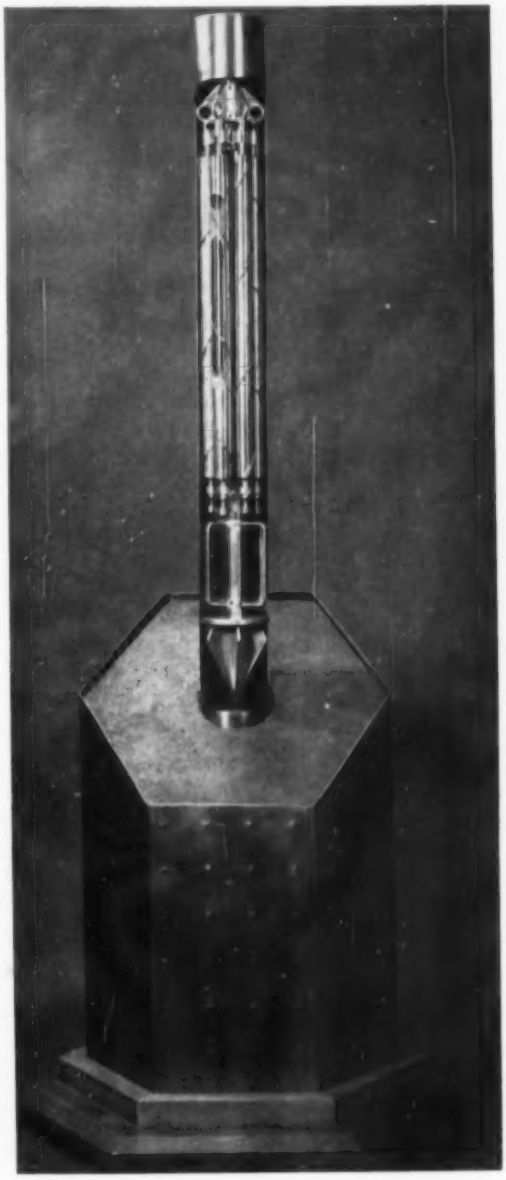


Fig. 2 – Cutaway Model of a Zirconium-Clad Moderator in the Sodium-Graphite Reactor Showing Fuel Element Located in the Central Tube Which Runs Through the Graphite Block. Zircaloy will be used in permanent cladding for graphite moderator blocks. Stainless will be used as cladding for fuel elements which will use slightly enriched uranium. (Courtesy Atomics International)

a load factor of about 0.8. The load factor of the Merchant Ship Reactor, on the other hand, is more uncertain, and may be lower. For this reason, break-even prices have been given for load factors of 0.8 and 0.4 for this reactor.

We should also mention that conditions assumed held constant when Zircaloy is substituted for stainless steel are: (*a*) the reactor's inventory of U^{238}; (*b*) the burn-up fraction, that is, the fraction of uranium in spent fuel which has been converted to fission products; and (*c*) the reactivity of spent fuel. When these conditions are held constant in the substitution of Zircaloy for stainless steel, the U^{235} content of fresh fuel may be reduced. Calculation of the magnitude of this reduction is an important step in evaluating the break-even price.

Value of Materials and Fabrication

Stainless steel was valued at $5 per lb., in place in the reactor. For every dollar per pound increase in this price, the break-even price of Zircaloy is increased by about the same amount. The price of cobalt-free stainless steel is more than this. When Zircaloy is considered as a substitute for cobalt-free stainless, the break-even price of Zircaloy is correspondingly higher.

The value of uranium, as a function of enrichment, has been taken from the A.E.C.'s price schedule which lists natural uranium at $39.27 per kg. and highly enriched uranium at $17 per g. of U^{235}. Both the cost of uranium in fresh fuel and the credit for uranium in spent fuel were evaluated from this schedule. The break-even price of Zircaloy is roughly proportional to the value of uranium. Plutonium, in spent fuel, was credited at $30 per g. – the A.E.C.'s present "buy-back" price. This price has little effect on the break-even price of Zircaloy, since the yield of plutonium is not greatly changed by the substitution of Zircaloy for stainless steel.

A rental charge of 4% per year is made against the value of the entire inventory of uranium in fuel fabrication, reactor cooling, reprocessing and spare fuel elements. This is the A.E.C.'s present rental charge. Figure 4 shows how the break-even price in the Yankee Reactor would be affected by changes in this rental charge. The break-even price of Zircaloy would be substantially higher if the rental charge were higher than 4%. This would be the case if enriched uranium were produced under ordinary commercial conditions.

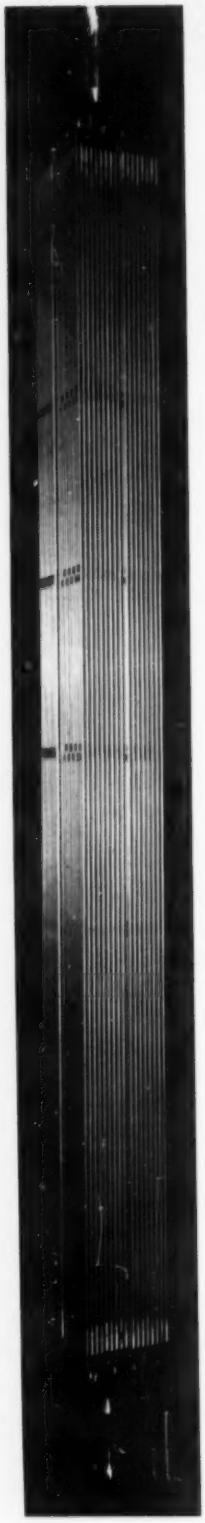


Fig. 3 – Yankee Atomic Electric Reactor Will Use Uranium Oxide Pellets (2.6% Enriched) in Stainless Steel Tube To Give a Fuel Rod With Length of 102 In.

Load Factor

Except for the Merchant Ship Reactor, it was assumed that each reactor operates at a load factor of 80%. This is a representative value for large, central-station power plants. Because the Merchant Ship Reactor may operate at lower load factors, the effect of changes in load factor on the break-even price of Zircaloy for this reactor was investigated.

The break-even price of Zircaloy used for permanent reactor parts increases with increasing load factor. The reason is that more fuel is put through the reactor and the annual savings made possible by the use of Zircaloy are greater. Since the amount of Zircaloy in the reactor is independent of load factor, its break-even price is higher, the higher the load factor.

When Zircaloy is used for fuel cladding, to be replaced with each charge of fuel, the amount of Zircaloy used per year increases with load factor proportionately more rapidly than does the annual savings. Then the savings per pound of Zircaloy and the break-even price *decrease* with increasing load factor. The trends shown in this part of our study suggest that if the load factor of the Merchant Ship Reactor is expected to be substantially under 80%,

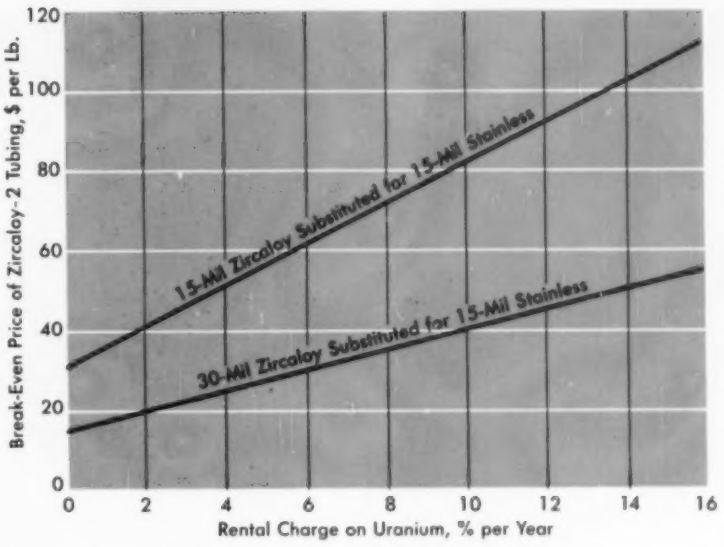


Fig. 4 – Effect of A.E.C.'s Rental Charge for Uranium on Break-Even Price of Zircaloy-2 Tubing Used To Clad Fuel in Yankee Atomic Electric Reactor. (Courtesy Columbia - National Corp.)

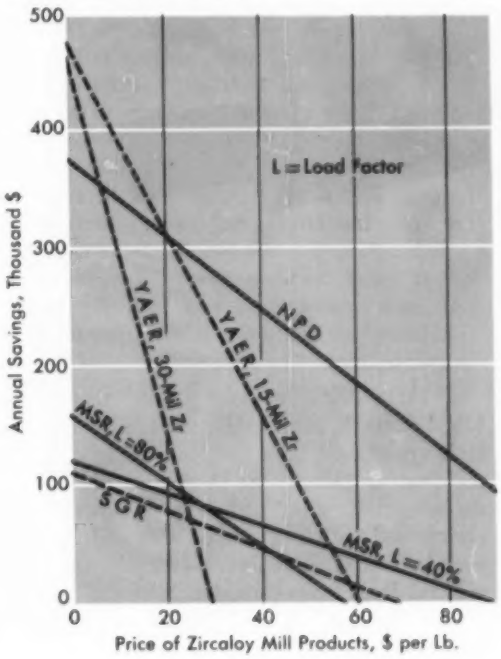
Zircaloy should be considered seriously for fuel cladding as well as permanent parts. Figure 5 shows annual savings from substitution of Zircaloy for stainless cladding for the reactors studied.

When the structural material is in a higher average neutron flux than the uranium fuel, the reduction in neutron absorption possible when Zircaloy is substituted for stainless steel will be greater, and the break-even price will be higher – in fact it is about proportional to the ratio of the average flux in structural material to the average flux in fuel.

In several of the reactors studied, structural material extends out of the core of the reactor into regions where there is no neutron flux. Since this extra material must be paid for, but saves no neutrons and does not contribute to reduction in fuel costs, the break-even price of Zircaloy is lower the more structural material is outside of the neutron flux.

The break-even price of Zircaloy is strongly dependent on the operating conditions of U^{235} enrichment, burn-out fraction, and rate of burn-up of fuel. Table I gives some idea of the effect of changes in these conditions on break-even price, but is not very informative because it is difficult to sort out the effect of one variable from another, when all are changed at the same time. Moreover, differences in flux ratios, effective cross sections, and other variables among these reactors further obscure any trends. Because of this, a separate study was made of the change in break-even price when operating conditions are changed one at a time in the same reactor. Results of this study are reported in Jacek Jedruch's S.M. Thesis in Nuclear Engineering at Massachusetts Institute of Technology. The study dealt with fuel cladding in the Sodium-Graphite Reactor. The results showed that break-even price decreases with increasing enrichment, increases with increasing burn-up fraction, and decreases with increasing fraction burned up per year. Although the study was made for the Sodium-Graphite Reactor, the results are approximately correct for other slightly enriched reactors with volume-for-volume substitution of Zircaloy for stainless steel.

Fig. 5 – Annual Savings in Direct Operating Costs When Zircaloy Is Substituted for Stainless Steel in Fuel Cladding. (Courtesy Columbia-National Corp.)





Vessel for Distilling 75% Acetic Acid at 265° F. and 30 Psi., Made of Bolted Sections of Aluminum Bronze Plate

Licking the Problem of Stress-Corrosion Cracking

*By JOHN F. KLEMENT, ROBERT E. MAERSCH and PATRICK A. TULLY**

High-pressure steam, either pure or containing acid or salt vapors, quickly causes intergranular cracks in aluminum bronze pressure vessels. Apparently grain boundaries are slightly enriched in aluminum, and this is oxidized preferentially. The trouble is permanently avoided by addition of a fractional percent of tin. (R1d, R4d, 2-60; Cu-s, *Al*, *Sn*)

ALUMINUM BRONZES, with their combined strength, formability, weldability and corrosion resistance, have been increasingly used in the process industry as sheet and plates, condenser tubes, pipe and bolts. However, an unexpected trouble interfered with wider acceptance by corrosion engineers – namely, the alloys cracked from stress-corrosion in steam.

Such spontaneous failures in stressed brass and bronze alloys under mild corrosive attack have caused more unpredictable difficulties than any of the more common types of corrosion. Only too often laboratory tests involving complete, alternate or line immersion have failed to indicate danger of premature failure.

The villain is steam – often carrying a minor amount of acids, alkalies or various salts. These

*Technical Director, Chief Research and Development Metallurgist and Research Metallurgist, respectively, Ampco Metal, Inc., Milwaukee, Wis.

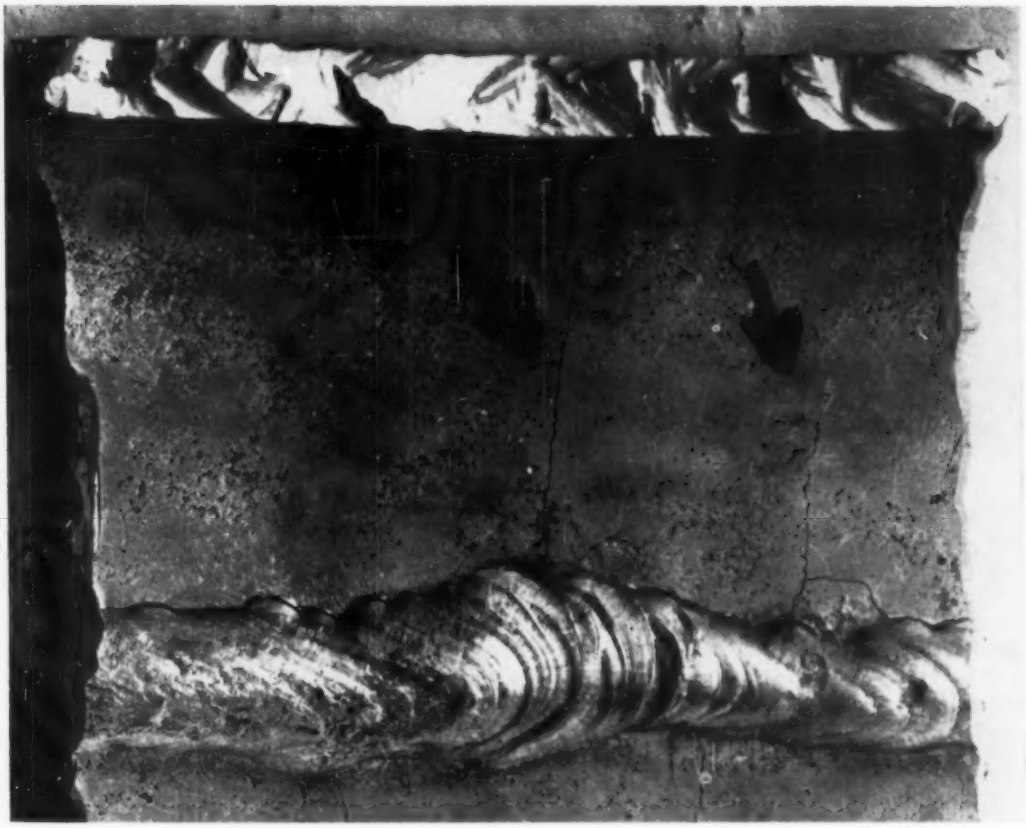


Fig. 1 — Typical Field Failure. Inside surface of an expansion joint fabricated from 91-7-2 Cu-Al-Fe plate, which was under very high fabrication and applied stress during operation in hot aqueous vapor

vaporous atmospheres cause trouble when residual or applied stresses are present in a pressure vessel or acid distillation unit operating from 180 to 500° F.

Material — The nominal composition and range of mechanical properties of the alloy of particular interest in this development are: aluminum 7.0%, iron 2.0%, other elements 0.5%, balance copper. The mechanical properties depend on work and heat treatment, and vary between the following limits:

Tensile strength	70,000 to 90,000 psi.
Yield at 0.5% strain	35,000 to 65,000 psi.
Elongation in 2%	40 to 25%
Reduction of area	25 to 55%
Brinell hardness (3000 kg.)	145 to 190

This alloy can be hot and cold worked by conventional methods of rolling, extrusion, forging, pressing, drawing, and heading. It can also be readily welded.

Failures reported to us over three years indicate a rather definite pattern, and restricted our corrective efforts to the commercial alpha aluminum bronzes, of which the 91-7-2 Cu-Al-Fe alloy mentioned above was typical. The path of the corrosion cracks was always intergranular, even when welded, although trouble usually favored weld deposits where fusion and heat affected zones existed.

Fabricated equipment such as shown at the head of this article is made from plates, hot rolled and cold formed into heads, shells and outlets. Welding is done with an aluminum bronze electrode of 89-10-1 Cu-Al-Fe composition which produced a deposit of predominantly alpha phase comparable in strength to the base plate. The typical failure in Fig. 1 shows the path of cracking along the edge of the weld; secondary cracks are normal to the weld and propagate into the plate. Such typical stress-corrosion cracks usually appear in fabrications or stressed members in a matter of weeks or months, depending upon the temperature of the corrosive steam and the intensity of stress. Stress-relieving after fabrication may often eliminate most of the

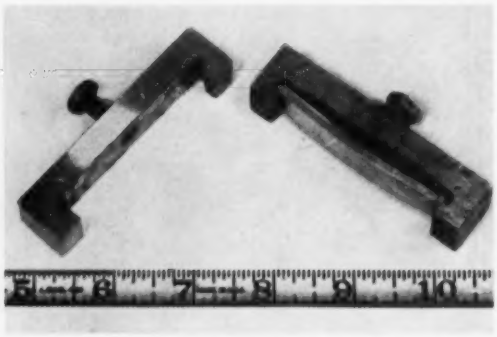


Fig 2 – Fixture for Stressing Small Bar to Accurate Amount in Bending; Mounted Specimen at Right. These are exposed to process vapors a week at a time in a small autoclave at 350° F.

residual or locked-up stresses but does not protect the metal against applied stress or thermal stress resulting from heating and cooling. A change in material is generally necessary to eliminate a basic weakness in any alloy susceptible to this type of failure. However, before a cure or an alternative composition can be found, fast laboratory tests must be devised to evaluate conditions and materials.

Accelerated Tests

In this testing program we attempted to reproduce the service conditions which resulted in actual field failures. Steam-tight stainless steel vessels were made of 5-in. pipe, 7 in. long, welded to a heavy base and having a screw-down top. Fixtures for stressing test specimens in bending are shown in Fig. 2. These were suspended on a perforated plate over a beaker containing either tap water or various acid solutions. The containers were then sealed and placed in a 350° F. oven for about one week. All specimens were then examined, and those which had not failed were exposed for an additional week.

Test materials were taken from production lots of sheet and plate of standard alloys, and from sheets of modified alloys processed by standard rolling-mill practice. The same materials were also butt-welded together with aluminum bronze filler rod. The test pieces and weldments were machined to specimens ⅛ in. thick, ⅝ in. wide and 2.75 in. long. The as-rolled surfaces of the sheet specimens and the faces of the welds were exposed in tension to the corrosive vapor. In order to accelerate failure, the bending stresses on the tension face of the specimens were relatively high – generally at the yield strength.

After various periods of testing, attention was given both to visible cracking and to incipient cracking under micrographic inspection. All specimens which apparently failed to crack after several test periods were polished, etched and examined microscopically. Specimens known to be susceptible to stress cracking were frequently withdrawn from the test at an early stage and the incipient cracks studied under the microscope. Cracks in these specimens bear an excellent resemblance to field failures with respect to location of cracks, appearance and microstructure. Specimens surviving the stress-corrosion tests without apparent cracking were bent 180° to verify their soundness.

About the same time is required to cause crack failures in either pure steam or in aqueous acid vapor. Welded specimens tended to fail a little more rapidly than parent plate specimens, regardless of the corrosive medium. The cracks were always intergranular. Welded specimens normally failed by incipient cracking in the

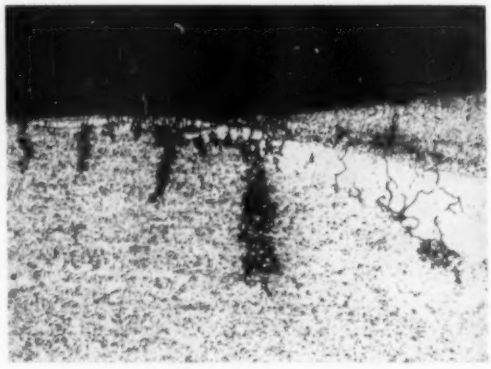


Fig. 3 – Incipient Cracks in Welded Specimen. The area to the upper right is the edge of the face of the weld deposit. The coarse-grained region underneath this is the heat affected zone. This specimen is of unmodified 91-7-2 Cu-Al-Fe alloy, and was exposed under 30,000 psi. stress to 350° F. steam and 70 hr. The existence of one principal crack and several smaller incipient crack paths is typical. 10% potassium dichromate etch, 50 ×

fusion zone; this crack then propagated through the parent plate or along the fusion zone. Figure 3 illustrates typical incipient stress-corrosion cracks in a welded specimen which was withdrawn from the test before complete failure.

While the primary purpose of this work was to find a cure for the cracking in the 91-7-2 Cu-Al-Fe bronze, some alloys used in similar field applications were included in the tests. These included other bronzes containing 5% and 8%

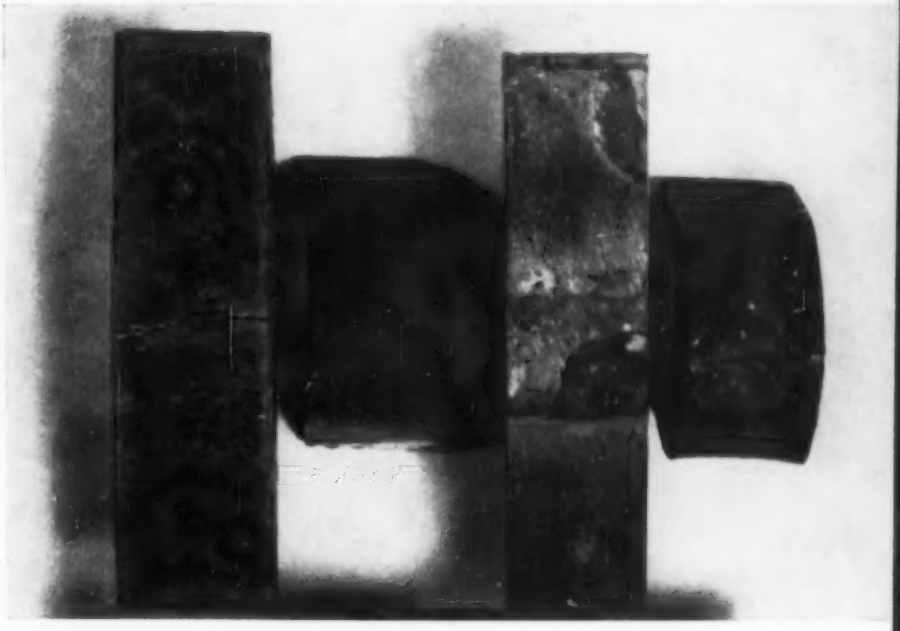


Fig. 4—The Specimens Shown Are All of the Basic 91-7-2 Cu-Al-Fe Alloy Stressed at 30,000 Psi. and Exposed to 350° F. Saturated Steam. The first, at left, is unmodified plate specimen after 150 hr. exposure; next is improved alloy after 3000 hr. exposure followed by bend test; No. 3 is a welded specimen of unmodified alloy plate after 150 hr. exposure, and No. 4 is a welded specimen of improved alloy plate after 3000 hr. exposure followed by a U-bend

aluminum, and a 3% silicon bronze. Although susceptibility to cracking, measured by failure time, varied with compositions, all cracked.

After studying various elements as alloy additives, it was found that a small amount of tin gave complete protection to the standard alloy, yet did not affect its other properties. For example, the average results of the stress-corrosion tests of plate specimens in 350° F. saturated steam are as follows:

Alloy	Time to Fail
5 Al, 95 Cu	550 hr.
7 Al, 2 Fe, 91 Cu	150 hr.
7 Al, 2 Fe, 91 Cu, 0.35 Sn	no failures after 3000 hr.
8 Al, 92 Cu	50 hr.
3 Si, 1 Mn, 95 Cu	200 hr.

Note that the failure time varies inversely with the aluminum contents, except in the one which was modified with tin. All laboratory efforts failed to produce stress-corrosion cracking in this modified alloy. Figure 4 gives vivid confirmation; specimens 1 (plate) and 3 (weldment) of the conventional 91-7-2 Cu-Al-Fe alloy were badly cracked after 150 hr. in steam; specimens 2 (plate) and 4 (weldment) of the same alloy *plus* 0.35% tin were undamaged and successfully passed the U-bend test.

Proving the New Material

After laboratory testing had indicated that the modified aluminum bronze alloy was no longer susceptible to intergranular stress-corrosion cracking in steam, it was decided to conduct tests more typical of field applications, so three experimental pressure vessels were made.

The first vessel was made of ¼-in. plate of the unmodified aluminum bronze. It consisted of a closed cylindrical shell 10 in. diameter, 20 in. high, with a top flange to which was bolted a ¼-in. cover. The bolts were made from extrusions of the same alloy. Inside the vessel a semicircular baffle plate was attached with a continuous single fillet weld. This vessel was equipped with safety valves, temperature and pressure-indicating equipment, and a controlled heating source. After filling the vessel about one third full of water, operation was begun at about 240° F. and 8 to 12 psi. gage pressure. Within a few weeks leakage began along the welded seams, and bolts failed regularly. The vessel was repaired repeatedly, but weld seam failures continued to occur until the vessel was retired from test after about 10 months of intermittent operation.

The second vessel is shown at the left of Fig. 5. It was similar in dimensions to the first, but was constructed of the bronze alloy modified with 0.30% tin. This vessel was operated with water at 265° F. and 24-psi. gage pressure for 13 months. No failures occurred. The water was then replaced with a 20% solution of acetic acid, and the vessel operated at 260° F. and 23-psi. gage for an additional period of over 6 months,

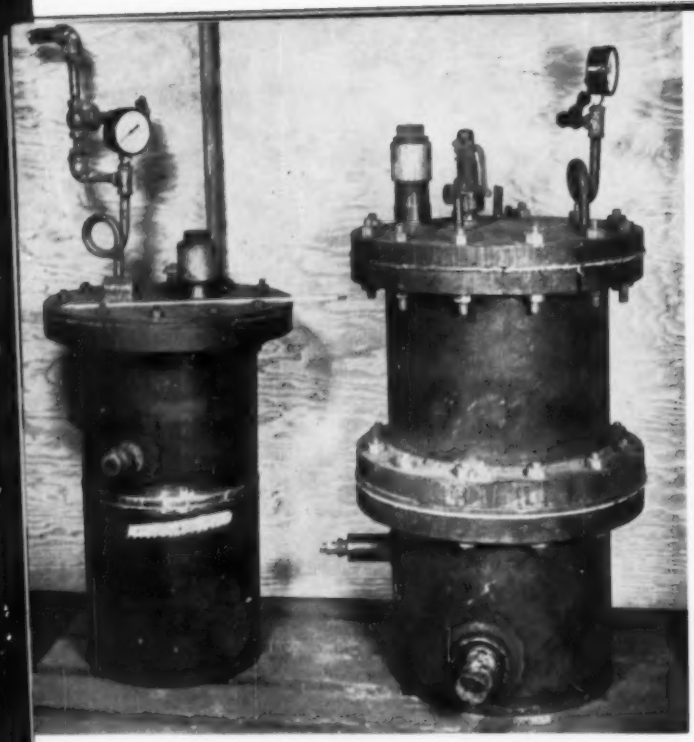


Fig. 5 – Experimental Test Pressure Vessels of Aluminum Bronze Containing 0.30% Tin. Left is the single-chamber boiler in which baffle plates are welded; it has operated successfully for many months with both steam and acetic acid. The vessel on the right is the sea water evaporator. Both have been in extended service without sign of stress-corrosion cracking

again with no sign of failure. Tests will be continued indefinitely using different solutions.

The third vessel (right, in Fig. 5) was constructed of 3/16-in. aluminum bronze sheet of the tin-modified alloy. It was made to resemble a salt water distillation unit which had previously failed in the field. This unit was made of two cylindrical shell sections 12 in. in diameter and 12 in. long, separated by a bubble cap plate, and bolted together through heavy flanges. Two cold formed "zig-zag" condenser units made from aluminum bronze condenser tube were inserted in the 1-in. head. One of the tubes was of conventional 93-7-2 Cu-Al-Fe alloy, while the other was of the same alloy modified with tin. These tubes were inserted in the stressed condition by intentionally misfitting the location of the entry and exit holes. Two pieces of the same tubing were bent to 140° return bends, stressed in a fixture, and laid on the bubble cap plate.

The lower section of this vessel was filled with sea water and the vessel heated to 260° F. and 23.4 psi. gage. The condenser tubes were air cooled by convection only, being open on the outside of the head.

Within the first week, steam began to issue from the outlet end of the unmodified alloy condenser tube. It was concluded that this tube had cracked, and after 90 days of service the head was removed and the tube was found to have failed completely. This failure was substantiated by the fact that the fixture-mounted specimen of the unmodified alloy tube had also failed.

It should be noted that the only sign of trouble in either of the vessels shown in Fig. 5 occurred in those parts made of the conventional bronze. The plate, welds, tubing and bolts made of 93-7-2 Cu-Al-Fe alloy modified with tin have withstood operating conditions for months.

Conclusions

A theoretical evaluation of the stress-corrosion problem indicates that the cause of the intergranular cracking is related to the segregation of the aluminum in the alpha grain boundaries. Here the aluminum is attacked and oxidized by steam, while the stress causes continual rupture of any protective oxide film which forms. This results in crack propagation and eventual failure.

Prevention of such attack must involve the elimination of equilibrium grain-boundary segregation of aluminum atoms. Months of futile experiments on processing proved that this could not be done through any modification of melting, casting, rolling or heat treating techniques (although methods were found which resisted failure for a longer time).

Addition of 0.35% tin to the aluminum bronze alloy produced the modified aluminum bronze alloy* we have named "Ampco Grade 8" and which has been found to have a very high (if not complete) resistance to intergranular stress-corrosion cracking. The addition of this amount of tin has no noticeable effect on any of the mechanical or physical properties of the alloy, nor on its forming or welding characteristics.

An extensive program of testing in both the laboratory and in pilot field applications has failed to produce failures in the modified alloy, while the same tests on the unmodified material have invariably resulted in stress-corrosion failures in a few days or weeks.

The benefits gained by the addition of tin to this alloy do not constitute a metallurgical mystery, but are explainable through accepted physical alloy theory and corrosion potentials. The theoretical details, while simple, are too lengthy to be discussed here and will be the subject of a future paper.

*Registered U. S. Patent Office.

Vacuum Metallurgy in Europe

*By A. M. AKSOY**

Melting techniques, particularly vacuum degassing, have progressed rapidly since World War II. Though vacuum induction and arc melting have not developed as they have here, their potential is beginning to interest fabricators who need better and more dependable alloys.
(C25, D8m, J-general, 1-73)

COMMERCIAL VACUUM MELTING began in the early 1920's at Hanau, Germany. Searching for a suitable replacement for expensive and scarce platinum-base thermocouple alloys, Wilhelm E. Rohn experimented with nickel-chromium alloys. His experiments led, in 1923, to the founding of the Heraeus-Vacuumschmelze A.G. From that time, Dr. Rohn's energy and foresight helped develop both vacuum-melted alloys and vacuum melting techniques. Though Rohn died in 1943, Hanau continued to grow as a vacuum center, and, since the end of the World War II, has become one of the most important in Europe. Here, two vacuum equipment manufacturers (Heraeus and Degussa) and one producer of vacuum-melted metals and alloys (Vacuumschmelze) are engaged in research, development and production in various phases of vacuum metallurgy.

Because of activities here and in other European centers, vacuum techniques have progressed appreciably and have been applied successfully to many metallurgical processes as a result of continuing improvements in pumps, sealing componds, furnaces and assemblies.

Even though European technological advances in vacuum metallurgy have been noteworthy, industrial growth has been slow compared with that in the United States. Europeans are slower to accept vacuum-melted steels and superalloys, and there is no vigorous jet engine industry in Germany and France.

For vacuum degassing, the situation is different. Its advantages have long been recognized in Germany and Russia, and as a result, it has been widely used.

Vacuum Induction Melting

There are a large number of small batch-type, vacuum induction melting furnaces operating in Europe. Similar to furnaces in this country, they have provisions for alloy additions, temperature measurements and sampling. In some furnaces (used primarily for low-melting metals and alloys), the melt is poured vertically through a tap hole in the crucible bottom. The hole is plugged with a tapered rod of the grade being melted; when the melt is ready to pour, the plug is melted by an auxiliary resistance heater or induction coil.

Particular attention has been given to the selection and installation of refractories. German equipment manufacturers, furnace operators and research institutes have cooperated to devise refractory mixes and sintering techniques. High-purity, properly sized electromagnesia is used widely. Some plants, however, prefer magnesia-alumina or magnesia-chromic oxide mixtures. Dry ramming is done in a manner so that uniform density is obtained throughout the lining. Sintering techniques, employing a graphite core, have been perfected so that fully sintered layers of the desired thickness, with glass-like surface, are obtained. Adherence to a predetermined time-temperature cycle during sintering is essential for satisfactory linings. The life per lining varies from 50 to 120 heats depending on the alloys melted and melting conditions.

One interesting development in Russia (though practical only on a small scale) is autocrucible melting. A charge of coarse powder is held within a shell of fine powder backed by refractories inside an induction coil. The particle size and power supply frequency are selected so that inductive coupling centers in the coarse powder. Thus, it melts within a sintered outer shell of the same metal.

A comprehensive range of special alloys is vacuum induction melted in Europe. These in-

*Manager, Applied Research Laboratory, Crucible Steel Co. of America, Syracuse, N. Y.

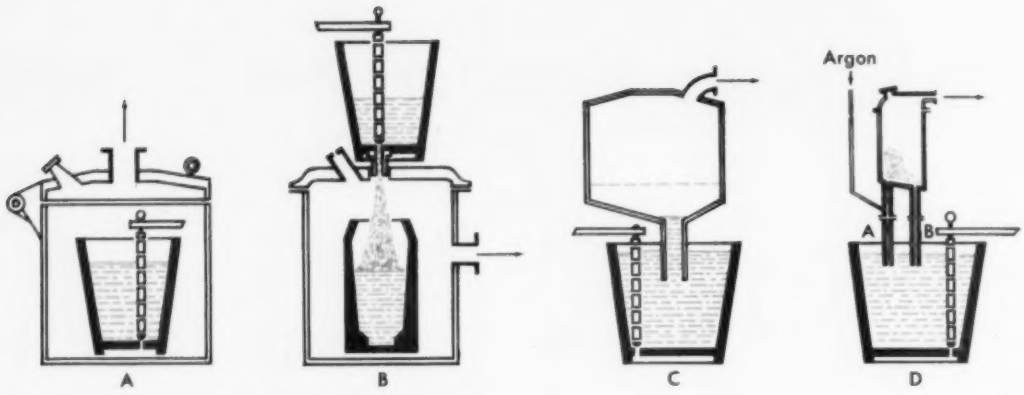


Fig. 1 – Four European Vacuum Degassing Techniques. They include ladle degassing and vacuum ingot degassing at Bochumer Verein (A) and (B), degassing by lifting at Dortmund-Hörder Hüttenunion (C), and degassing by recirculating at Heraeus-Ruhrstahl (D)

clude superalloys (Nimonic type), resistance heating alloys (Ni-Cr or Ni-Cr-Fe type), thermal-expansion alloys and bi-metals (Ni-Fe alloys), electronic and tube construction alloys (Ni-Fe and Ni-Co-Fe alloys, and pure Cu, Ni and Fe), soft magnetic alloys (Ni-Fe and Fe-Co type), alloys containing beryllium (up to 2.5%), nuclear reactor metals, steels for high fatigue and impact strength and other special alloys of high quality.

Vacuum melting is employed because a high degree of freedom from gases and inclusions and close control of composition are needed. The production of vacuum induction melted superalloys and bearing steels is small. European manufacturers are still not convinced that the high cost of these materials is warranted by the improved properties. As quality requirements are raised, production of these alloys will probably increase.

Vacuum Arc Melting

As in the U.S., vacuum arc melting of reactive and refractory metals received wide attention during the past decade in Europe and a number of installations were made. The biggest furnaces are capable of producing steel ingots weighing about 10,000 lb., but still larger furnaces are being designed. Companies using vacuum arc melting furnaces in production include Metallwerk Plansee in Austria; Ugine, Péchiney and Centre d'Etude Nucléaire de Saclay in France; Imperial Chemical Industries and William Jessop and Sons in Great Britain; Friedrich Krupp, W. C. Heraeus, Degussa, Deutsche Edelstahlwerke, Vereinigte Deutsche Metallwerke, Vacuumschmelze A.G. in Germany; Montecantini in Italy; A. B. Nynäs Petroleum in Sweden; and several plants in the U.S.S.R.

Most of these furnaces are for the production of reactive metals, such as titanium and zirconium. However, due to the slump in the titanium industry a year ago and growing interest in vacuum arc remelted steels, some companies are producing steels and superalloys.

European experience with vacuum arc melted alloys parallels that of the United States. They have also found that arc remelting reduces gas content and segregation, and increases fatigue strength and transverse elongation. Because of the low cost (as compared with vacuum induction melted materials), vacuum arc remelted steels and superalloys continue to interest Europeans; reports show the demand will increase.

In the reactive metal field, Europeans are trying to increase titanium production. Efforts include development of stronger alloys, price reductions and new commercial applications. Much German titanium is used in chemical process equipment. Zirconium is used in nuclear reactors and limited quantities of columbium, tantalum, uranium and chromium are produced for special applications.

Vacuum Degassing

To eliminate flaking in large, heavily alloyed forgings, steelmakers have been trying to reduce the hydrogen in molten steel since 1935. No method provided full guarantee against flaking until vacuum degassing was tried. In 1950, Bochumer Verein began experiments. This work resulted in three production methods: ladle degassing, stream-droplet degassing and vacuum ingot casting. In the following years, two other processes, based on different principles, were developed by Dortmund-Hörder Hüttenunion and Heraeus-Ruhrstahl.

The principles of various methods are illus-

trated in Fig. 1. In all of these processes, the metal is melted and refined by conventional means, and treated with vacuum in the ladle or during pouring. In ladle degassing (A), the ladle is placed in the tank, which is then evacuated. Violent boiling allows gases to escape from the steel. Pouring in the conventional manner follows the treatment.

For ingot casting (B), a chamber containing an empty ingot mold is evacuated. The filled ladle is placed on the cover, the entry to the chamber being sealed by a sheet of aluminum. When the ladle is opened, the molten metal fuses the aluminum, enters the vacuum chamber, and splits up into droplets. This provides a most favorable condition for degassing.

In the Dortmund-Hörder process (C), the degassing vessel is lowered, and a siphon is inserted into the ladle to draw in a small quantity of molten metal. After degassing, the liquid steel is returned to the ladle by raising the vessel. This cycle is repeated until the ladle is degassed to the desired degree.

Heraeus-Ruhrstahl has devised the most recent vacuum degassing technique (D). A glance at Fig. 1 will show its operation. Tubes A and B, of a degassing converter, are immersed into the molten steel. When the converter is evacuated and argon is blown into Tube A, a portion of the metal rises into the vacuum chamber. The metal is degassed rapidly, due to its large surface attained by the use of argon. It travels back to the ladle through Tube B, and collects at the bottom because of its higher specific weight. Meanwhile, another quantity of metal is sucked up from the upper portion of the ladle and goes through the same cycle. By this continuous process, 100 tons of steel can be vacuum degassed in the relatively short time of about 15 min. Temperature drop is small; an induction heater can be used to compensate for heat losses. An example of this type of unit, at Henrichshütte of Ruhrstahl A.G., is shown in Fig. 2.

The vacuum maintained in most European degassing operations ranges from 1 to 10 mm. mercury; hydrogen is reduced by 50 to 90%. Not only is hydrogen lowered but up to 40% of nitrogen and up to 75% of oxygen are removed as well. Cleanliness and mechanical properties improve, though the extent of improvement depends on the type of steel and varies from one plant to another.

Vacuum degassing is used quite extensively in Europe. All types of carbon, low-alloy and stainless steels are degassed in Germany. Most of the alloy steels degassed are for heavy forgings, such as turbine shafts and rotors. According to reports, ten ladle degassing and four stream degassing units in Russia are used for bessemer rail steel, transformer steel, alloy constructional steels, stainless and cast steels.



Fig. 2 – Vacuum Degassing at Henrichshütte, Ruhrstahl A. G.

Vacuum Heat Treating

Of particular interest is the growth of vacuum heat treatment. Highly gas-sensitive metals, such as molybdenum, tantalum and tungsten, cemented carbides and ceramic materials, are sintered in vacuum to obtain higher densities and improved properties. To remove nitrogen, oxygen and carbon, most European permanent magnet manufacturers also use vacuum sinter. Watt losses of silicon steel have been reduced to a low value by heat treating transformer sheet in vacuum on a large scale.

Metal powders of high purity are produced by careful balancing of carbon with oxygen prior to vacuum treatment. Similarly, the carbon in ferrochromium (which contains enough oxygen to react completely with carbon) is reduced by annealing in vacuum at 2250° F.

Research work on various phases of vacuum metallurgy in many European research centers is under way, particularly in Germany and Russia. This should result in new applications of vacuum techniques.

High-Strength Steel Can Be Cadmium Plated Without Embrittlement

By D. J. CASH
and W. SCHEUERMAN*



Fig. 1 – Parts Are Blasted With Aluminum Oxide (180-Mesh) Before Plating. Dry blasting aids inspection and cleans the surface for plating. No wet cleaning or pickling is used. (Photographs courtesy of Apex Hard Chrome Co., Inc.)

Cadmium is plated from a cyanide bath at 70 amp. per sq.ft. to give a porous plate which permits hydrogen to diffuse out of the surface in subsequent bake. A sustained load specimen, of much higher sensitivity, replaces the unnotched tensile test piece. This new specimen is designed so it must fail when plated with the older standardized procedures. (L17c, Q26s; ST, SGB-a, *Cd*)

CADMIUM PLATING is used extensively as a coating for aircraft landing gears. In the last few years, a great deal of effort has been put forth, both by academic and industrial workers, to develop a method for plating cadmium so the advantages of the coating might be utilized without the danger of hydrogen embrittlement. Working with Douglas Aircraft Co. and Lockheed Aircraft Corp., and with the cooperation of our plating vendors, we have developed a plating process and a control procedure which gives a functional cadmium plate without embrittlement.

A review of literature on the subject and our electroplating experience leads to the following considerations:

- There exists a threshold value of hydrogen concentration for a steel, at a certain heat treat level, above which embrittling effects can be detected by a prescribed test.
- Embrittlement is a surface or subsurface phenomenon.
- Hydrogen-inducing operations such as pickling and electroplating result in a subsurface hydrogen concentration which is high, initially.†
- Upon baking, hydrogen migration takes place at a rate consistent with the hydrogen gradient, temperature and properties of the material through which diffusion must take place.
- A dense, impervious electroplate has a low coefficient of diffusion – approaching zero for the temperature range used in relieving high-strength steel. Hydrogen will diffuse inward

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†"Effect of Baking on Delayed Fracture of Electroplated Ultra High-Strength Steel", by B. F. Brown, NRL Report 4839, 1956.

until equilibrium is reached and perhaps outward at an infinitely slow rate. If the equilibrium level is below the threshold concentration for the test employed, embrittlement will not be detected.

• If the electroplate is sufficiently porous, its diffusivity constant will be high. This means the bulk of the hydrogen will diffuse outward since it is initially subsurface.

Results from work of many investigators indicate that the amount of hydrogen needed to embrittle high-strength steel is extremely small. It seems likely, then, that until a plating process is developed which is 100% effective in preventing embrittlement, the extreme caution practiced in producing aircraft structural members will require some kind of embrittlement relief. Since porosity in the plate helps, any feature which will promote porosity will be advantageous.*

Plating Process Used

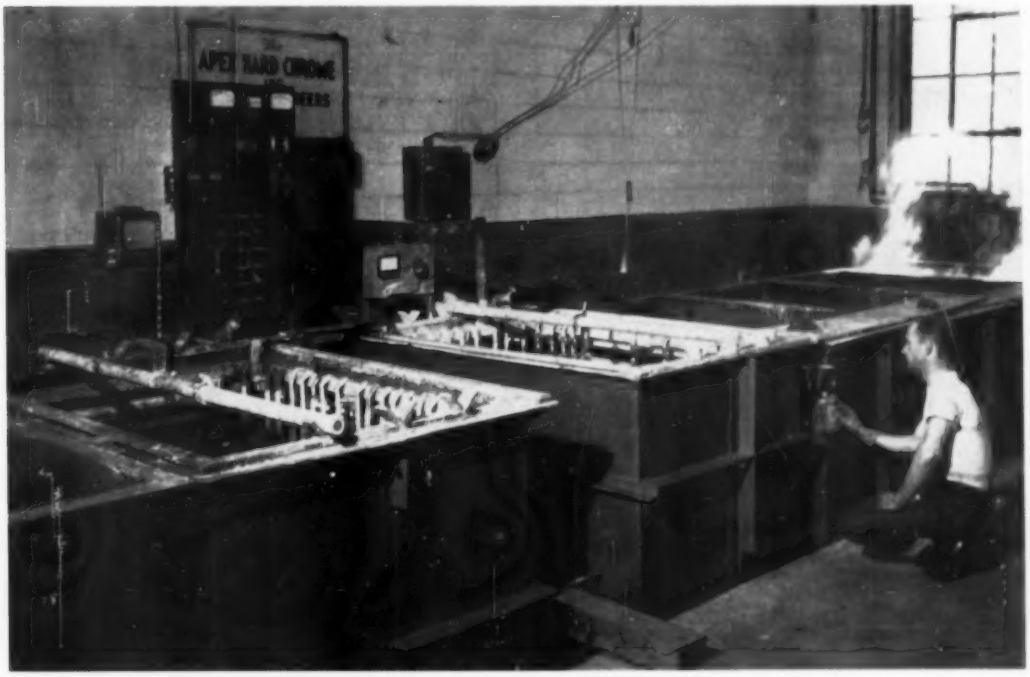
Basically, the plating process used at Cleveland Pneumatic is intended to produce a relatively porous plate (Fig. 1 to 3). Porosity results from three conditions: (*a*) elimination of brighteners from a standard cadmium plating bath; (*b*) use of a finely dry-blasted surface on parts to be plated (this also eliminates cleaning operations which may induce hydrogen into the metal); (*c*) deposition of cadmium at an average current density of 70 amp. per sq.ft., which is well within the porous range for the bath composition employed. (A typical cadmium solution contains 2.9 to 5.5 oz. per gal. of cadmium as CdO and 12 to 20 oz. per gal. of sodium cyanide.)

After plating, parts are baked for 23 hr. for hydrogen relief. While it is likely that this long bake is on the conservative side, it is certainly not harmful, and has the added effect of stabilizing any retained austenite which may be present in the base material.

In an earlier attempt to prevent embrittlement, we restricted plating thickness to a flash coat using a maximum time of 2 min. in the plating cycle. With our new method, the full 0.0003 to 0.0005-in. thickness can be deposited with no effect on hydrogen relief. Because of the sacrificial function of cadmium plate, it is important to apply the full plate thickness. Upwards of 800

*"Techniques of Cadmium Electroplating Reduce Hydrogen Embrittlement", by W. F. Hamilton, SAE Preprint No. 218, 1957.

Fig. 2 – Plating Time Is Set on the Automatic Timer Which Shuts Off the Current at the End of the Required Plating Cycle. Current versus time is recorded on the instrument to the left of the panel. Small parts requiring 50 amp. or less are placed in series with a sensitive meter and rheostat. Auxiliary anodes are frequently used to get uniform current density on complex parts



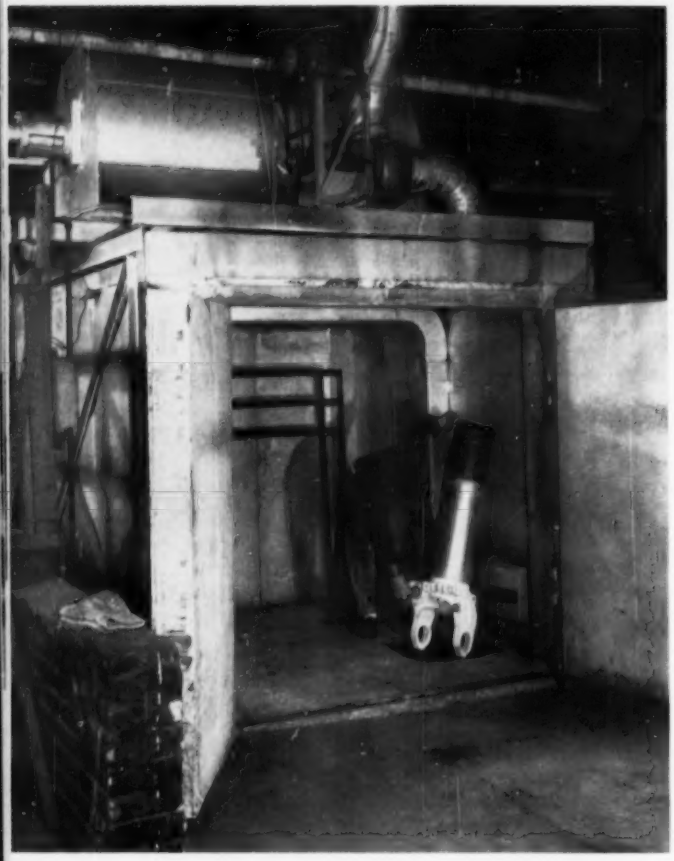


Fig. 3 – After Plating, Parts Are Baked for 23 Hr. at 390° F. to Remove Hydrogen Induced in the Plating Operation

hr. of salt spray resistance is obtained (standard 20% salt solution) from panels plated as outlined on the preceding page.

Initially we controlled the process by use of three ¼-in. diameter unnotched tensile specimens plated concurrently with each batch of parts. The specimens were tested to destruction in tension, and the reduction in area was compared with a standard developed for unplated specimens. Most of the data given in this article were obtained from tensile specimens made under production conditions. While test specimens represent the results to be obtained from a given processing sequence, they do not, in reality, exactly duplicate a part, whether processed simultaneously or not. We felt it was best to rely on a system of process control, based on control of the variables affecting the part, once a system was developed which would result in embrittlement-free plating.

The most significant variable affecting the porosity of the plate, and subsequent embrittlement relief, was found to be current density. The only way to insure that each part is plated at the minimum current density required is to: (*a*) plate parts in batches of identical or similar parts, (*b*) record significant data from each batch, (*c*) record, automatically, the current versus time for each batch. This gives a permanent record of the exact conditions used for these two significant variables.

The bath analysis is not of much consequence so long as it is maintained within relatively broad specification limits. Nevertheless, it is reported on an ampere-hour basis and these values can be related directly to the sequence of production



Fig. 4 – Rings After Plating (Right) and Stressed for Sustained Load Test (Left)

parts. The inclusion of plating specimens on a work shift basis provides a running check of the process to control such things as malfunctioning instrumentation and the operator's error.

Production Results

Over the years, we have used a number of methods to plate high-strength steel. The results are summarized in the following paragraphs based on tests with unnotched tensile specimens.

1. From November 1954 to June 1955, a standard cyanide cadmium plating solution was used at 17 to 23 amp. per sq.ft. Brighteners and conventional wet cleaning and pickling methods were used. Parts were plated at 0.0003 in. minimum thickness, then given a bake of 8 hr. at 360° F. plus 24 hr. at 250° F. Out of a total of 312 lots plated, 60 were rejected, for a rejection rate of 19.2%. The highest rate in any one month was 47.8%.

2. From June 1955 to October 1955, a flash plate (2 min. maximum) was deposited at 40 to 60 amp. per sq.ft. using a standard cadmium plating bath containing a brightener. Out of 392 lots, 32 were rejected, for a rate of 8.1%. The highest rate in a single month was 15.1%.

3. From November 1955 to the present time, a portion of our high-strength parts were flash plated in a cyanide solution (containing brightener) at 60 amp. per sq.ft. A regular caustic cleaner and acid pickle were used. Parts were baked for 10 hr. at 375° F., plus 24 hr. at 250° F. Out of 2163 lots, 115 were rejected, for a rate of 5.3%. Highest rate in a single month was 20%.

4. From August 1957 to November 1957, a portion of the high-strength parts were flash plated at 60 amp. per sq.ft. in a cyanide bath, with no brightener. Standard cleaning and pickling were used. Parts were baked for 23 hr. at 375 to 400° F. Out of a total of 279 lots, two were rejected, for a rate of 0.7%.

5. From December 1957 to present time, a portion of the high-strength parts were plated according to the new process described in this article. Out of 646 lots, there were no rejections.

New Control Specimen

Since August 1957, a number of special control specimens of high sensitivity were run along with unnotched tensile tests. (The procedure for this particular test was furnished by Douglas Aircraft Co.) These specimens are made of 4340 aircraft quality steel. The steel is checked to be sure it is susceptible to hydrogen embrittlement before use. To do this, test rings are plated in a standard bath. They are then baked for 8 hr. at 375° F. and stressed for the test. Rings must fracture within 24 hr. or the heat of steel is not acceptable for use as test material. Specimens are in the form of 2.5-in. O.D. cylinders (Fig. 4), heat treated to 260,000 to 280,000 psi. These rings are stressed beyond their yield point by inserting them into a vise (with rubber pads on jaws) and distorting to allow insertion of the stress bar. This gives a sustained load which remains until the ring breaks. Fracture before seven days is considered failure.

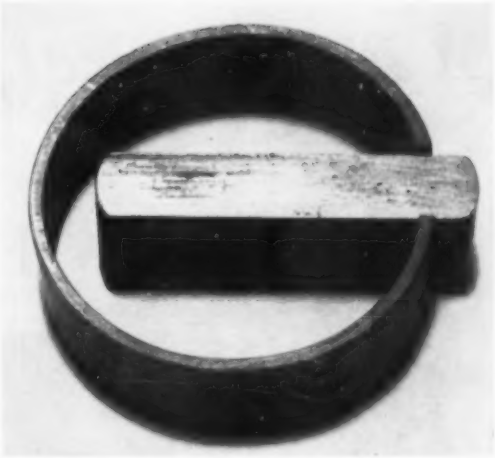


Fig. 5 – Ring That Failed Under Test. To be acceptable, rings must not fracture or crack for seven days. (Actual size)

From August to November 1957, out of 80 lots plated as in No. 4, above, the rejection rate was 21% with the ring-type specimen. Using the tensile-type test specimens with the No. 4 procedure, the rejection rate was only 0.7%. This indicates the increased sensitivity of the sustained load test. From December 1957 until the present, sustained load tests were used to test parts plated by the new procedure. Out of 124 lots, there have been no failures attributable to hydrogen embrittlement.

The plating method and control set forth above have been embodied in a process specification which has been fully accepted by our plating vendors as a reasonable and necessary control document. In essence, this specification embodies the basic principle: When aircraft quality is involved, it is essential that processing specifications contain the vehicle for enforcement. It is not sufficient to merely describe a process – it is necessary to place it under a system of rigid, but workable, process control.

A Biographical Appreciation of an





Clarence H. Lorig

Eminent Living Metallurgist

Clarence H. Lorig
President, American Society for Metals 1958-59;
Technical Director, Battelle Memorial Institute.
First Recipient of the William Hunt Eisenman Medal
of the Philadelphia Chapter

SCIENTIST, ADMINISTRATOR, TEACHER, COUNSELOR – Clarence Lorig has been, and is, all of these. To those who know him best, Clarence Lorig is more. He is an understanding and accessible friend, whose sincere humility is an encouragement to the young engineer in need of counsel, and an example to the veteran research scientist.

The new president of the American Society for Metals, at the pinnacle of his career, is a metallurgist of proved executive ability holding down a key position in scientific research. This is a refreshing situation at a time when the country's top scientists are often called upon to provide the leadership needed in important executive and administrative posts. The gain to management is often a severe loss for the laboratory, and the process is rarely reversible.

As technical director at Battelle Memorial Institute, he is responsible for the excellence of much of the metallurgical research there. Clarence's output is tremendous. Nearly a hundred technical papers and articles and more than a dozen patents bearing his name attest to his large contribution to metallurgical knowledge.

His productive career, however, has not made him less accessible to his colleagues, who recognize in him a man of scientific breadth and human understanding. He has encouraged the free interchange of ideas by making himself always available – to the tyro as well as to his veteran colleagues – for the discussion of theoretical and practical problems. It would be difficult to estimate what those consultations have contributed in wiser technologists and better solutions to problems. Never sparing of his own efforts, he has always been kindly and considerate of others. In his quiet way, Clarence Lorig has encouraged many promising young engineers and scientists, at the same time imparting to them his own high standards of technical accuracy and preciseness in reporting results of research. The many engineers and technologists who have worked with him and who now are holding positions of responsibility, both at Battelle and elsewhere, provide an indication of the fruitfulness of his leadership and guidance.

All his 39 years of professional activity have been devoted in one way or another to the science of metals. During his long years of activity in metallurgy, Clarence has helped to set patterns of research that have since become traditional. He has steadfastly adhered to standards of technical excellence, and to clarity in technical writing. His leadership, aid, and communication of his own knowledge of the field have helped earn for the metallurgical profession the recognized excellence it enjoys today.

The recognition accorded by his fellow members of the American Society of Metals in conferring the presidency on him is the culmination of the several forms of recognition Clarence has received from various sources. One of these was the invitation to deliver the Campbell Memorial Lecture before the 1951 World Metallurgical Congress. That lecture was well-named "A Metallurgist Looks at Fracture". Calling attention to the fact that conventional assumptions regarding metals as being homogeneous and isotropic are at variance with the true nature of metals, he pointed the way toward broadening the theories and concepts of metals fracture.

In the same year, 1951, the college of engineering of the University of Wisconsin, where he had earned all his degrees and performed early research, presented to Dr. Lorig its citation for

distinguished engineering services. A year earlier, 1950, he had received the Joseph S. Seaman Gold Medal for distinction in metallurgical research from the American Foundrymen's Society. By the Government, for his contributions to the work of the War Metallurgy Committee, Clarence was awarded the Armed Forces Certificate of Appreciation in 1948.

The choice of Clarence H. Lorig as the first recipient of the William Hunt Eisenman Medal by the Philadelphia Chapter ASM is another of his well-deserved honors – "In recognition of your outstanding dedication and service to the American Society for Metals, development of aims of the Society and in recognition of your leadership in guiding and stimulating research in the field of refractory metals and alloys for the advancement of the metals industry".

Clarence Lorig joined Battelle Memorial Institute in 1930 after a year of engineering research at the University of Wisconsin and a year as assistant professor at Drexel Institute. Battelle had just opened its doors. Its first director, Horace Gillett, was surrounding himself with bright young men who were destined to lead that organization along challenging paths. His selection of Clarence Lorig proved to be a sound one. Much of the Institute's stature today in the field of metallurgy stems from Clarence's leadership and scientific talents.

At Battelle, where his career and the course of the Institute parallel each other in the stature both have attained over the past 28 years, Clarence has guided research in a number of areas. On some of his early published papers, his findings were reported in co-authorship with metals scientists whose names – such as Cyril Stanley Smith and Horace Gillett – indicate the pioneering scope and scientific depth that Lorig was inevitably to bring to metallurgical research. Reports of studies in which he has engaged embrace such areas as alloy development, heat treatment, metallurgical practices, production methods, and behavior of steels and cast irons. Much of our knowledge of copper and phosphorus as useful alloys in irons and steels resulted from his studies. His patents cover developments in the making of steels, alloys, and cast iron, the surface cleaning of metals, the improvement of valves, and the design of molds. Over the years he has given much attention to such metals as tungsten, molybdenum, titanium, zirconium and chromium. His interests in these areas of study have encompassed problems associated with a variety of demands over the past three decades. He has helped guide the technological adjustments required by the depression era, the war years, the atomic age, and now the space age.

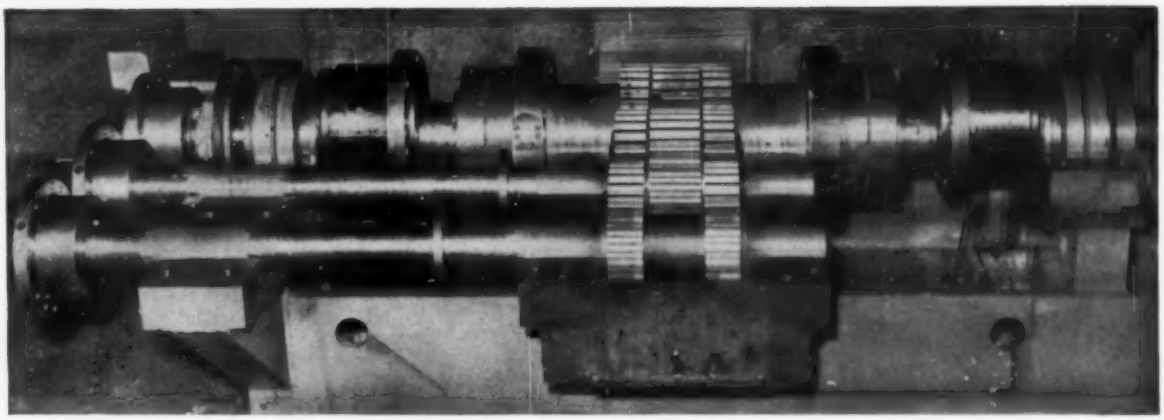
The technical societies with which Clarence is affiliated indicate that his interests in fields allied to metallurgy are broad, and his circle of colleagues in industry, science, and engineering – not surprisingly – likewise is broad. In addition to his membership in the American Society for Metals, he is also a member of the American Institute of Mining, Metallurgical, and Petroleum Engineers, American Foundrymen's Society, American Society for Testing Materials, the Society of Automotive Engineers, Institute of British Foundrymen, and the Alloys of Iron Research Committee of the Engineering Foundation. His effective leadership and willingness to assume responsibility appear clearly in the effort he has expended for these societies in committee activities, acceptance of office, and counsel in many phases of their respective programs.

It would almost seem that Clarence has had little time for anything but his professional career, but he has a broad range of other interests and hobbies. In his younger years he played better-than-average baseball, basketball and golf. He now devotes much free time growing flowers which are out of season or foreign to Ohio, such as rhododendron, azalea, aconite, and winter roses. Even with this avocation he has not been content to stay in his own back yard but has been a source of information and encouragement to his friends and neighbors who in turn have elected him president of their Kingswood Garden Club.

Clarence's attractive wife, Esther, provides the charm and grace that so exemplifies the wholesomeness of the Lorig family. Marjorie, their daughter, is now in her first year at Cornell. Their son Bruce is now with the Navy, having earned a Naval ROTC appointment to Cornell. Bruce's hobby of sailing also attracted Clarence, and he is an active member of Leatherlips Yacht Club.

In this setting, one might expect to find a man who might let the pride of his accomplishments slip through. But all of his friends and associates have been impressed by the modesty and lack of self seeking of Clarence Lorig. There is no doubt that this supreme characteristic is the key to the spirit which he inspires in all who have the good fortune to know, love, and respect him.

J. H. Jackson



Assembled main shear shaft and front gate drive shaft used in model 541 guillotine flying shear. Shafts range up to 9¼" in diameter and 16' in length. All shafts are fabricated of type 4340 nickel alloy steel.

Giant "flying" shears need...

Nickel alloy steel for fatigue strength and shock resistance in heavy shafting

Cutting metal strip is a shaft breaking job!

It takes enormous blade pressures applied as much as 180 times a minute 250,000 times a day. That's rough on the shafting that activates the shears.

How does The Hallden Machine Company design shafting to take this kind of punishment?

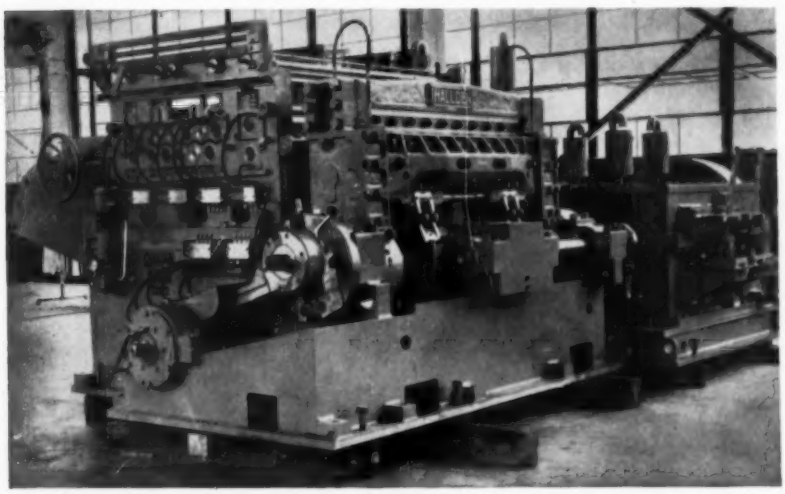
They do it with 4340 nickel-chrome-moly steel.

Some shafts are as large as 9¼ inches in diameter. But even in these heavy sections, 4340's good response to heat treatment provides the toughness and fatigue resistance needed.

For these reasons, type 4340 is now standard for bull . . . main shear and drive box shafting and all other heavy-duty shafting. The extra stamina it delivers pays off for Hallden customers in long, dependable service.

Do you have a difficult or new design problem that demands a material with special properties? If so, you might find exactly what you need in one of the standard grades of nickel alloy steel.

The booklet "The Properties of Heat Treated Wrought Nickel Alloy Steels" helps you choose the right steel for the job. It gives you useful information on the many different nickel alloy steels and describes their range of properties. Heat treatment methods . . . for both carburizing and direct hardening steels . . . is explained in detail. Ask for a copy of this helpful bulletin. We'll be glad to send it to you.



Hallden guillotine flying shear. Nickel-chrome-moly steel, heat treated to a nominal hardness of 260 Brinell and tensile strength of 125,000 pounds per square inch provides the properties needed for heavy-duty shafting in shearing machines. Built by The Hallden Machine Co., Thomaston, Conn.

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall St. New York 5, N. Y.

INCO
TRADE MARK

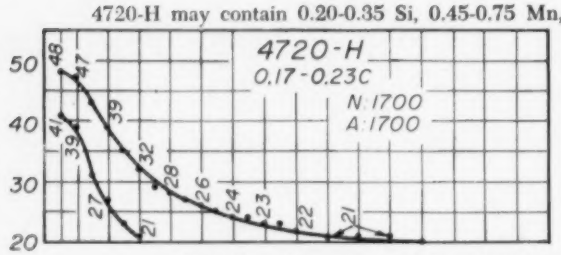
INCO NICKEL

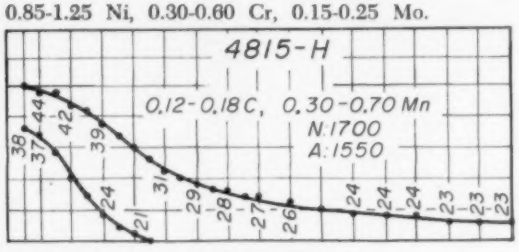
NICKEL ALLOYS PERFORM BETTER, LONGER

Hardenability Bands for Steels 4720-H to 50B60-H

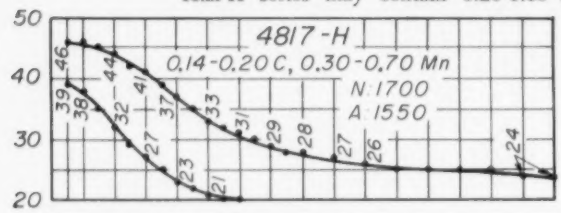
A.I.S.I. List of July 1958

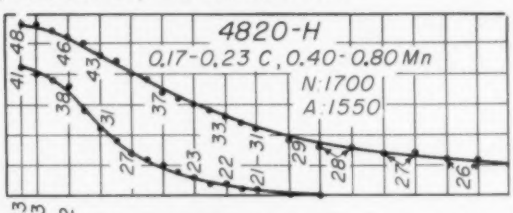
4720-H may contain 0.20-0.35 Si, 0.45-0.75 Mn, 0.85-1.25 Ni, 0.30-0.60 Cr, 0.15-0.25 Mo.

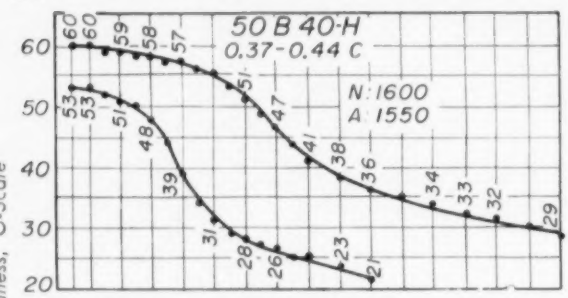


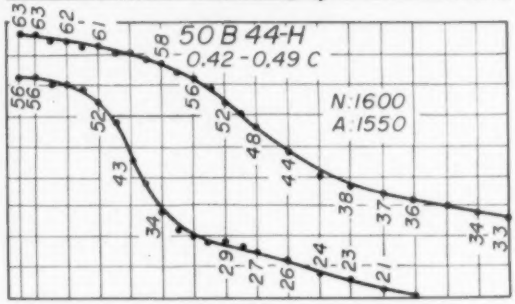


48xx-H series may contain 0.20-0.35 Si, 3.20-3.80 Ni, and 0.20-0.30 Mo.

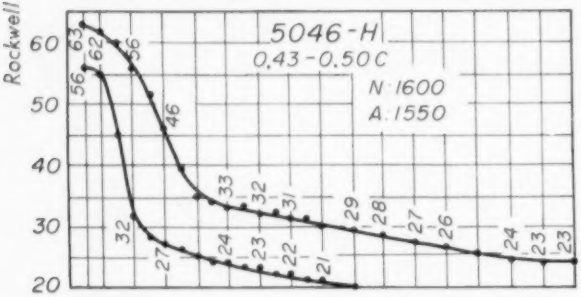


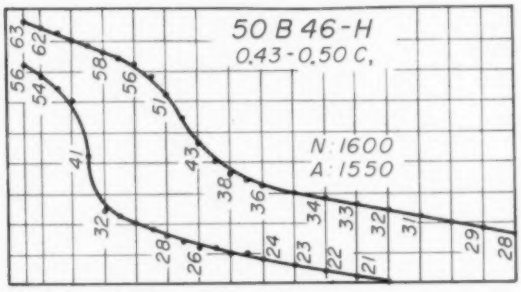


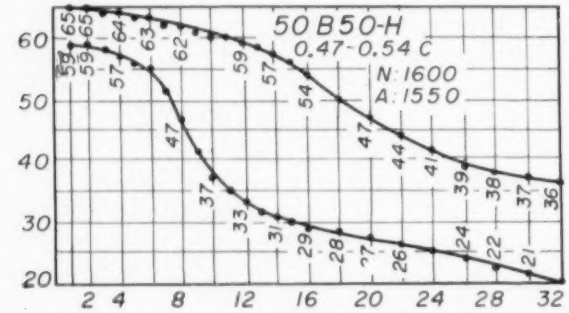


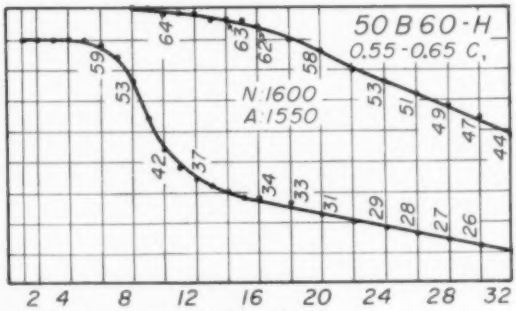


50xx-H series may contain 0.20-0.35 Si and 0.65-1.10 Mn. 5046-H and 50 B 46-H contain 0.13-0.43 Cr. Other 50 B xx-H steels contain 0.30-0.70 Cr. The boron or B-steels can be expected to have 0.0005 min. B.









Rockwell Hardness, C-Scale

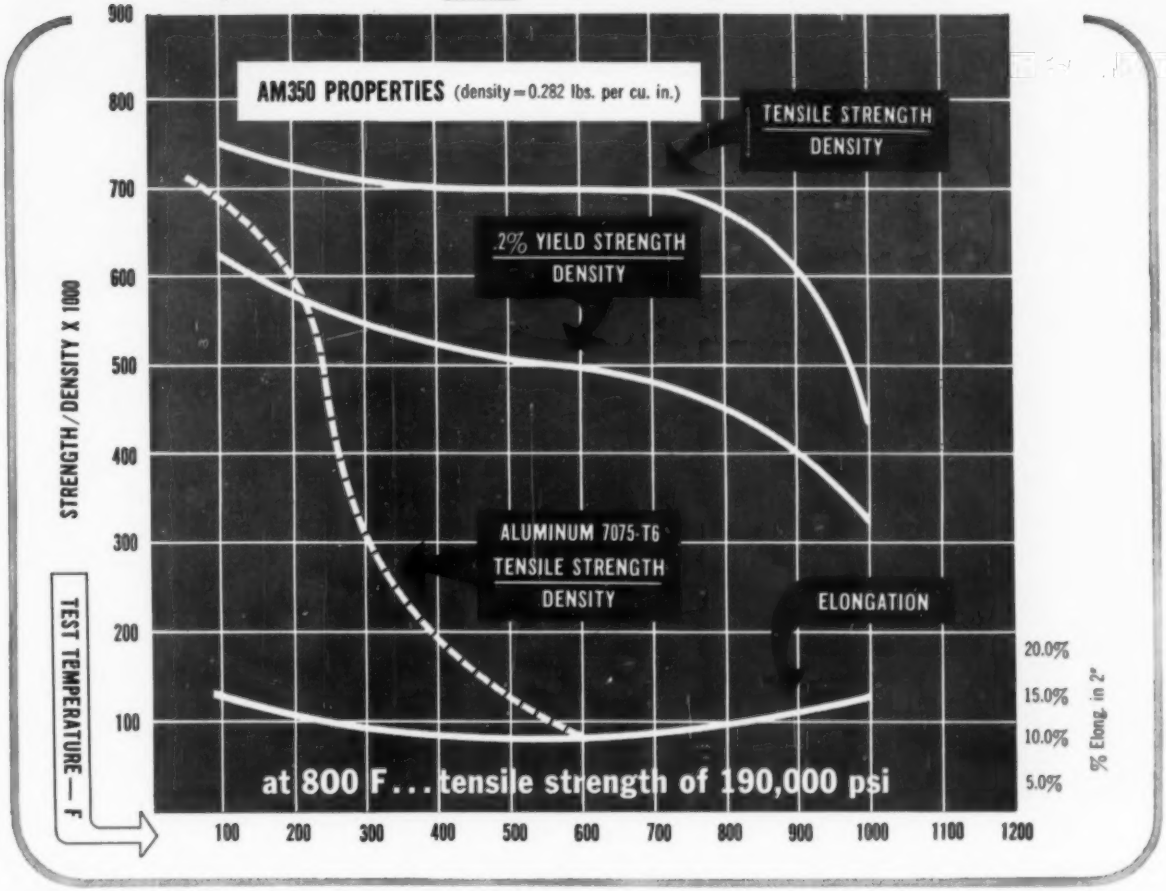
2 4 8 12 16 20 24 28 32

Distance From Quenched End of Specimen, Sixteenths

N means normalizing temperature for forged or rolled material; A means austenitizing temperature (both as recommended by S.A.E.).

Hardness limits are specified in Rockwell C-scale units (no fractions) and can be scaled from the plotted points where not labeled at even sixteenths.

Experience**—the extra alloy in **Allegheny Stainless



Here are the facts on AM350 and AM355, Allegheny Ludlum's precipitation hardening stainless steels

A unique combination of highly desirable properties is the usual description of Allegheny Stainless AM350 and AM355 Steels. They combine high strength at both room and elevated temperatures, excellent corrosion resistance, ease of fabrication, low temperature heat treatment, good resistance to stress corrosion.

They are proving the answer to many problems of the air age. Airframe and other structural parts, pressure tanks, power plant components, high pressure ducting, etc. are all natural missile and supersonic aircraft applications for AM350 and AM355.

Availability: AM350, introduced several years ago, is available commercially in sheet, strip, foil, small bars and wire. AM355, best suited for heavier sections, is available in forgings, forging billets, plate, bar and wire.

Corrosion resistant: Being stainless steels, these alloys resist corrosion and oxidation. Compared to the older, more familiar stainless grades, their corrosion rating is better than the hardenable grades (chromium martensitic) but generally less than the old corrosion resistant standbys, the 18 and 8's. Stress corrosion is resisted at much higher hardness levels than with martensitic stainless.

Simple heat treatment: High strength is developed by two methods, both involving less than ordinary temperatures and minimizing oxidation and distortion problems. The most popular, and one that develops slightly better properties, is the Allegheny Ludlum developed sub-zero cooling and tempering (SCT condition). The material is held at minus 100 F for 3 hrs plus 3 hrs at 850 F. Alternate method is Double Aged (DA): 2 hrs at 1375 F plus 2 hrs at 850 F.

Easy fabrication: AM350 and AM355 can be spun, drawn, formed, machined and welded using similar procedures as with the 18-8 stainless types. In the hardened condition (SCT & DA) some forming may be done . . . 180 degree bend over a 3T radius pin. Also it can be dimpled in the hard condition to insure accurate fit-up.

For further information, see your A-L sales engineer or write for the booklet "Engineering Properties, AM350 and AM355." ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*** Address Dept. MP-14.

WBW 7327

ALLEGHENY LUDLUM

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EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

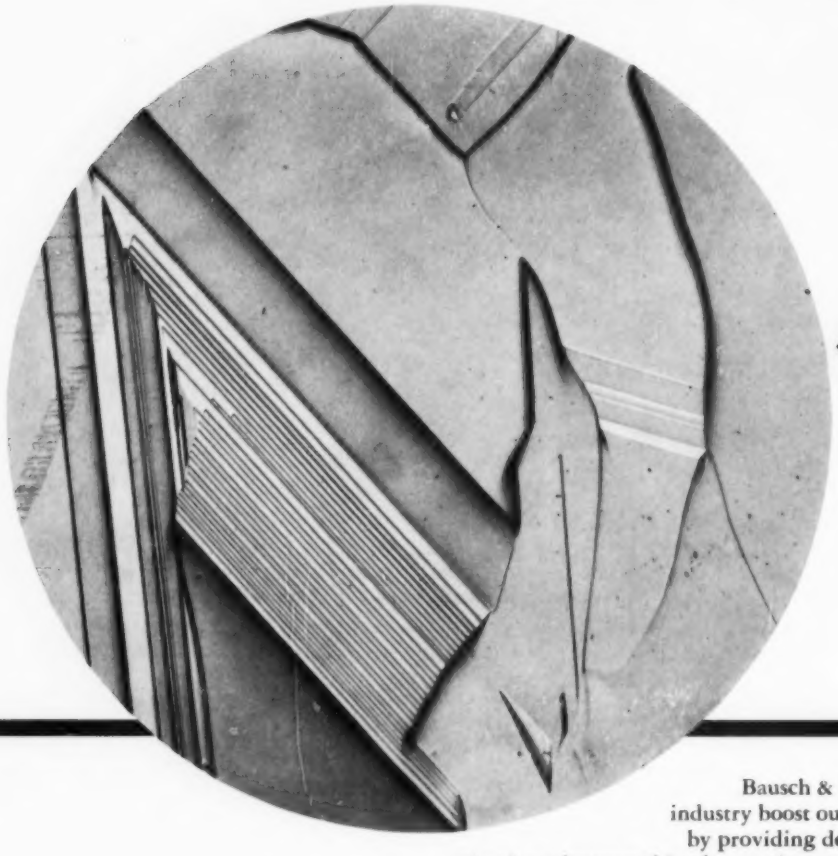
Bausch & Lomb Salutes:

John H. Miller

Blue Ribbon Award Winner, 1958 A.S.M. Metallographic Exhibit



BLUE RIBBON AWARD WINNER for the best photomicrograph in the class of *Metals and Alloys Not Otherwise Classified*—Mr. John H. Miller, Sylvania Electric Products Inc., Towanda, Pa.

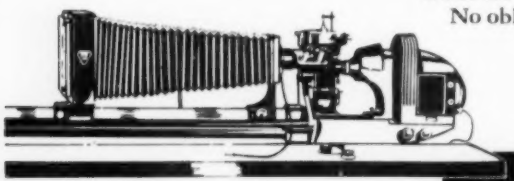


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SINCE 1853

11th Western Metal Congress

Consolidated Program

Los Angeles, March 16 through 20, 1959

American Society for Metals ⊕
American Welding Society (A.W.S.)
Society for Nondestructive Testing (S.N.T.)
American Institute of Mining,
Metallurgical, and Petroleum Engineers (A.I.M.E.)
A.S.M. Woodside Panel Conference (W.P.C.)

All Meetings at
Ambassador Hotel, Los Angeles

Monday, March 16

9:00 a.m. – ⊕ Selection Criteria – Effects of Service Experiences and Changes in Performance Requirements
9:00 a.m. – S.N.T. Educational Session
2:00 p.m. – ⊕ Selection Criteria II
2:00 p.m. – A.W.S. Welding Techniques
2:00 p.m. – S.N.T. Educational Session

Tuesday, March 17

9:00 a.m. – ⊕ Effects of Advances in Mill Practices on Materials
9:00 a.m. – A.W.S. Welding Techniques
9:00 a.m. – A.I.M.E. Recent Advances in the Physics of Metals
9:00 a.m. – S.N.T. Workshop Seminar
2:00 p.m. – ⊕ Effects of Advances in Intermediate Fabrication Techniques on Materials
2:00 p.m. – A.W.S. Panel Discussion on Brazing
2:00 p.m. – A.I.M.E. Metallurgy of Thermo-Electric Materials
2:00 p.m. – S.N.T. Workshop Seminar

Wednesday, March 18

9:00 a.m. – ⊕ Effects of Advances in Fabrication Techniques
9:00 a.m. – A.W.S. Welding Techniques
9:00 a.m. – A.I.M.E. Materials for Extremely High Temperatures
9:00 a.m. – S.N.T. Workshop Seminar
2:00 p.m. – ⊕ and A.W.S. Welding of Pressure Vessels of Ultra-High-Strength Steel
2:00 p.m. – A.I.M.E. Radiation Effects in Materials
2:00 p.m. – S.N.T. Workshop Seminar

Thursday, March 19

9:00 a.m. – ⊕ Fabrication and Reliability Problems of Specific Alloys
9:00 a.m. – W.P.C. Explosive Forming I
9:00 a.m. – A.W.S. Arc Welding and Weldability
9:00 a.m. – S.N.T. Research Session
2:00 p.m. – ⊕ Fabrication and Reliability Problems of Specific Alloys
2:00 p.m. – W.P.C. Explosive Forming II
2:00 p.m. – A.W.S. Welding Quality Control
2:00 p.m. – S.N.T. Research Session

Friday, March 20

9:00 a.m. – W.P.C. Explosive Forming III
9:00 a.m. – S.N.T. Research Session
2:00 p.m. – W.P.C. Explosive Forming IV
2:00 p.m. – S.N.T. Research Session

American Society for Metals

Theme: Progress In Metals Technology

Monday, March 16

Effects of Service Experiences and Changes in Performance Requirements

9:00 a.m. — Selection Criteria I

Aircraft Airframes
E. A. Green, Douglas Aircraft Co.

Aircraft Power Plants
D. E. Hanink, Allison Div., General Motors Corp.

Solid Propellant Missile Airframes
L. E. Zwissler, Aerojet-General Corp.

Liquid Propellant Missile Power Plants
P. R. Vogt, Rocketdyne Div., North American Aviation, Inc.

2:00 p.m. — Selection Criteria II

Petroleum Industry
G. R. Prescott, C. F. Braun & Co.

Chemical Equipment
G. A. Nelson, Shell Development Co.

Power Generation Equipment
G. B. Grable, W. A. Bechtel Corp.

Tuesday, March 17

9:00 a.m. — Effects of Advances in Mill Practices on Materials

Panel Discussion: Melting in Vacuum and Protective Atmospheres

Stainless Steels and Superalloys
W. W. Dyrkacz, Allegheny Ludlum Steel Corp.
and *D. E. Nulk*, Tapco Div., Thompson Products, Inc.

Low-Alloy Steels
A. Nagy and *F. M. Richmond*, Universal-Cyclops Steel Corp.

Lithium-Aluminum Alloys
E. H. Spuhler, Aluminum Co. of America

Sandwich Rolling
E. Van Meter, United States Steel Corp.

Close-Tolerance Rolling
V. W. Whitmer and *T. E. Perry*, Republic Steel Corp.

Taper Rolling
K. F. Thornton, Aluminum Co. of America

2:00 p.m. — Effects of Advances in Intermediate Fabrication Techniques on Materials

Panel Discussion: Improvements in Quality Control of Castings
Panel Members: W. A. Bailey, Douglas Aircraft Co.
F. R. Drahos, Byron Jackson Pumps
F. C. Kroft and *G. A. Fritzlen*, Haynes-Stellite Co.
W. R. Roser, Northrop Corp.

Precision Forgings
D. Honebrink, Boeing Airplane Co.

Compressively Stress-Relieved Forgings
R. Smallman-Tew, AVRO Aircraft, Ltd.

Wednesday, March 18

9:00 a.m. — Effects of Advances in Fabrication Techniques

Forum Discussion: Carbon Control in Heat Treating Steel
Moderator: L. Schapiro, Douglas Aircraft Co.
Commentators: N. Koebel, Lindberg Engineering Co.
O. E. Cullen, Surface Combustion Corp.
W. R. Varney, Calmec Manufacturing Co.
R. H. Lundquist, California-Doran Heat Treating Co.
M. Tiktinsky, Lockheed Aircraft Corp.
J. C. White, North American Aviation, Inc.

Panel Discussion: Reduction of Warpage

By Creep Forming and Die Quenching of Nonferrous Alloys
J. Soja, North American Aviation, Inc.

By Die Quenching of Steel
T. R. Bradley, Rohr Aircraft Co.

By Thermal Cycling of Aluminum Alloys
H. N. Hill, Alcoa Research Laboratories

Society for Nondestructive Testing

The S.N.T. program (not yet available at the early press date required by this issue of *Metal Progress*) will cover five full days. Monday, March 16, will be devoted to educational sessions. Tuesday and Wednesday will feature workshop seminars on steel castings, wrought aluminum and nondestructive testing of nuclear components. Research papers will be presented on Thursday and Friday. The annual Mehl lecture will be given Wednesday afternoon.

2:00 p.m. — Pressure Vessels (Joint Session With American Welding Society)

Problems With Thin-Wall Pressure Vessels of Ultra-High-Strength Steel
D. F. Gunder, Engineering Consultant

Panel Discussion: Welding Problems With Thin-Wall Pressure Vessels of Ultra-High-Strength Steel
Panel Members: A. J. Williams, United States Steel Corp.
G. B. Pritchett, Solar Aircraft Co.
W. Tenner, Solid Rocket Plant, Aerojet-General Corp.
E. P. Owen, Firestone Tire and Rubber Co.

Panel Discussion on Forming
Explosive Methods
S. R. Carpenter, Convair
and *A. H. Peterson*, Lockheed Aircraft Corp.

Hydro Spinning
J. N. Heater, Harrop, Packard and McCone

Thursday, March 19

9:00 a.m. — Fabrication and Reliability Problems of Specific Alloys

Forum Discussion: Hydrogen Embrittlement of Ultra-High-Strength Steels
Moderator: R. P. Frohmberg, Rocketdyne Div., North American Aviation, Inc.
Commentators: P. W. Kloeris, Douglas Aircraft Co.
G. G. Wald, Lockheed Aircraft Corp.
B. F. Brown, Naval Research Laboratory
A. M. Adair, Wright Air Development Center
C. E. Moeller, Menasco Mfg. Co.

Upgrading Via Specifications
K. F. Thornton and *J. F. Faulkner*, Aluminum Co. of America

Magnesium-Thorium Alloys
R. E. Bockrath, Dow Chemical Co.

Titanium and Titanium Alloys
W. S. Lyman and *C. T. Olofson*, Battelle Memorial Institute

2:00 p.m. — Fabrication and Reliability Problems of Specific Alloys

Stainless Steels 17-17 PH and AM 350
C. M. Walker, Pilotless Aircraft Div., Boeing Airplane Co.

Stainless Steel Type 431
C. C. Angstadt, Douglas Aircraft Co.

Stainless Steels 301 and AM 355
M. Watter, Budd Co.

High-Temperature Alloy A-286
L. J. Hull, Ryan Aeronautical Co.

American Society for Metals

Woodside Panel Conference on Explosive Forming

Thursday, March 19

9:00 a.m. — Explosive Forming I

Why Explosive Forming
- Reasons for Use
- Areas in Which Practicable
- Advantages and Limitations

Theories
Methods

Materials Formable
- Sizes
- Compositions

Amount of Deformation
Effect of High-Energy-Rate Impact

2:00 p.m. — Explosive Forming II

Energy Sources
- Cartridge
- Simple Charges

Shaped Charges
Sheet Explosives

Energy Transmittal Media
- Air
- Water
- Plastic

Talc
Other

Friday, March 20

9:00 a.m. — Explosive Forming III

Dies and Die Materials
- Steel
- Epoxies
- Plaster
- Wood

Ring Dies
Closed Dies
Male and Female Dies
Other

2:00 p.m. — Explosive Forming IV

Production Applications (Parts Now in Production or Successfully Produced in the Past)

Other Applications of Principles
- Compacting
- Forging
- Bonding
- Hardening

Casting
Hole Punching
Riveting
Embossing

American Institute of Mining, Metallurgical, and Petroleum Engineers

Tuesday, March 17

9:00 a.m. — Advances in Physics of Metals

The Physical Chemistry of Semiconductors
Harvey Winston, Hughes Aircraft Co.
Contribution of Magnetism to Solid State
(Speaker to be announced)
Present Status of Dislocation Theory
(Speaker to be announced)

2:00 p.m. — Thermo-Electric Materials

Review of Principles of Thermo-Electric Engines and Thermo-Electric Materials
P. H. Miller, Jr., General Atomic Div., General Dynamics Corp.
Thermo-Electric Properties of Lead and Bismuth
E. H. Lougher, Battelle Memorial Institute
The Use of Oxide Semiconductors and Mixed Valency Compounds in Thermo-Elements
W. D. Johnston, Westinghouse Electric Corp.
Evaluation and Properties of Materials for Thermo-Electric Applications *F. D. Rossi*, Radio Corp. of America

Wednesday, March 18

9:00 a.m. — Materials for High Temperatures

High-Temperature Properties of Graphite
Leon Green, Aerojet-General Corp.
High-Temperature Properties of Wand Mo
Robert W. Hall, Lewis Research Center, NASA
Advances in High-Temperature Molybdenum Alloys
Gordon W. Barr, Climax Molybdenum Co.

2:00 p.m. — Radiation Effects in Materials

Environment of Radiation Effects *J. M. Denny*
Survey of the High-Altitude Radiation
John Lindner, Ramo-Wooldridge Space Technology Laboratory
Motion of Radiation-Induced Defects in Copper
R. M. Walker, General Electric Co.
Electrical Effects of High-Intensity Ionizing Radiation
V. A. J. Van Lint, General Atomics
Radiation Effects in the Noble Metals
John Brinkman, Atomics International

American Welding Society

Monday, March 16, 2:00 p.m.

Welding of Low-Alloy High-Strength Tools in the Missile Industry *G. F. Harkins*, Solar Aircraft Co.
Welding of Thin-Gage Aluminum for the Aircraft Industry *R. J. Longerbeam*, Royal Industries, Inc.
Welding of High-Temperature Materials
Mario L. Ochicano, Lockheed Aircraft Corp.
Fusion Welding of Precipitation Hardening Steels
Russ Meredith, North American Aviation, Inc.

Tuesday, March 17, 9:00 a.m.

Automatic Unionarc Applications on Bridge Fabrication
C. A. Zwissler, Kaiser Steel Corp.
New Semi-Automatic Welding of Structural Steel
Leighton W. Johnson, Gunderson Bros. Corp.
Recent Advances in Welding Power
R. Henderson, Metal and Thermit Co.
Tungsten-Arc Cutting of Austenitic Stainless Steel
G. A. Conner, General Electric Co.

2:00 p.m. — Panel Discussion on Brazing

Brazing Fluxes *Stan Cross*, Engelhard Industries
High-Temperature Brazing *Harry Lewis*, Pyromet Co.

Wednesday, March 18, 9:00 a.m.

Tape-Controlled Heliarc Spot Welding
R. L. Hackman, Linde Co.
Welding on Thor Ground Support Equipment
C. B. Smith and *P. W. Hookey*, Douglas Aircraft Co.
Evaluation of 17-4 PH and PH 15-7 Mo Precipitation Hardening Stainless Steel Weldments
Harold Smallen, Northrop Aircraft, Inc.
A Practical Design Approach to Resistance Weld Peeling Loads *Wm. P. Kraus*, North American Aviation, Inc.

2:00 p.m. — Joint Session With A.S.M. on Pressure Vessels **(See p. 99)**

Thursday, March 19, 9:00 a.m.

Problem Areas in the Heliarc Welding of a Highly Stressed Pressure Vessel
Wm. Sponheimer and *P. C. Simmons*, Hughes Aircraft Co.
Weldability of Thorium-Magnesium Alloys
Harlan Meredith, Airline Welding & Engineering Co.
Inert-Gas Tungsten-Arc Welding of Titanium for Nuclear and Chemical Industries
G. M. Adamson and *W. J. Leonard*, Union Carbide Nuclear Corp.

Thursday, March 19, 2:00 p.m.

Quality Control of Spot Welding Shear Strength
W. A. Soward, North American Aviation, Inc.
Experimental Design in Welding
J. E. Hurzeler, North American Aviation, Inc.
Fusion Welder, Continuous Recertification
Lyle C. Curran, North American Aviation, Inc.
46,200 Welds per Sec. Speed Sandwich Assembly
C. A. van Pappelendam and *C. C. King*, Missile Div., North American Aviation, Inc.



Book Review

Brazing Processes, Equipment and Procedures

*Reviewed by WILLIAM M. LEHRER**

BRAZING MANUAL, Prepared by the Brazing Committee, American Welding Society. Reinhold Publishing Corp., New York, 200 p. $4.75.

IN THIS MANUAL we have a readable working guide to a little understood yet effective joining process. It is a useful source of answers to most questions arising in the more elementary and common brazing problems.

The organization of the material and the simplicity of the presentation are both beyond reproach. Starting with an introductory chapter which defines brazing processes and procedures, the authors describe in succeeding chapters the properties of base metals, brazing filler metals, fluxes and atmospheres, design criteria, brazing techniques, post brazing operations. The manual devotes 11 chapters to specific metals or groups of metals, and the last chapter deals effectively with the important question of safety and health protection.

A person totally unfamiliar with the brazing process can conveniently read selected chapters and establish a working knowledge of specific applications because of the independent organization of the book material. In this connection it is truly a handbook. Assume, for example, the desire to braze aluminum parts. A chapter on aluminum and aluminum alloys describes in minute detail why, how and where to braze these materials. The reader is presented with explicit information; first a general discussion of the aluminum brazing processes and brazable materials (and the pitfalls to expect when joining them) followed by a description of filler metal compositions, material preparation, joint types and their expected performance, how to dip braze, furnace braze, and torch braze. The chapter winds up describing post brazing cleaning procedures.

The material is well cross-referenced so that background information on any given subject may be obtained easily and quickly from other chapters. The manual is copiously illustrated with diagrams and photographs of applications. With luck, the reader may discover an illustration of the exact assembly he wants to braze.

This very arrangement has one drawback, however, for the reader who takes a cover-to-cover approach, since the later chapters are repetitious.

At the very beginning the authors caution the reader that "no analysis of a subject that is continuously being improved can hope to be complete. Nor can the subject be covered with the thoroughness which would satisfy the specialist." In the latter instances the manual does fall far short. The specialists—and there are admittedly few—may be disappointed. A bibliography is lacking, as are suitable tables and curves illustrating some of the fundamental properties of the brazed joint. For example, the chapter on joint design includes specific recommendations for certain applications but gives little or no explanation of the metallurgical and mechanical processes. The question "Why?" can be raised constantly in this particular chapter, but many of the omissions are due rather to the nonexistence of information than to neglect. In the reviewer's opinion, the authors chose wisely as to the safe degree of theory to maintain; the result is a manual that is fundamentally sound. The specialist and metallurgical research worker should certainly not avoid the manual since it offers many short-cuts bypassing the tedious trial-and-error process that is so often involved in the choice of brazing parameters.

The appendix consists essentially of a table entitled "Properties of Brazable Metals and Alloys". This is a laudable addition since it places at one's fingertips reliable data often difficult to locate such as composition, yield strength, tensile strength, elongation, melting range, coefficients of thermal expansion, and resistivity of numerous commercial alloys listed under commercial names. This table has many uses, even beyond the field of brazing.

The manual is an important and timely publication for anyone faced with modern joining problems. It is said that two heads are better than one; the Brazing Manual has had the benefit of 32—the Brazing Committee of the American Welding Society.

*Research Metallurgist, Armour Research Foundation of Illinois Institute of Technology, Chicago.

Three New Low-Hydrogen Iron-Powder Electrodes

*By D. C. SMITH and W. G. RINEHART**

Three new electrodes have been developed for high-strength weldments which will respond to heat treatments such as are used in aircraft. Tests show that the weld metal matches hardness and tensile strength of the base at tempering temperatures between 450 and 1250° F. (W29h, Q-general; AY, SGB-a)

*Chief Metallurgist and Research Metallurgist, respectively, Electrode Division, Harnischfeger Corp., Milwaukee, Wis.

THE PREVAILING APPROACH to composition of steel weld metal considers that all steel is low-carbon type with or without alloy additions. The weld metal is expected to meet all the mechanical properties required of it regardless of the analysis of the base metal and heat treatment used.

Steels used in welded fabrication can conveniently be divided into three groups: low-carbon or mild steel (less than 0.25% C); medium-carbon (0.25 to 0.45% C); and high-carbon grades (above 0.45% C). The greatest tonnage comes from the first group.

Electrode Requirements

Since mild steel is easiest to weld, a large variety of electrode types are available. Also, light and medium mild steel sections generally do not require preheat or postheat treatments.

The medium-carbon steels require more specialized electrodes, perhaps containing a small amount of alloy. They also call for greater welding skill, generally some preheat – the amount varying with the carbon content of the base metals and section thickness.

The high-carbon group requires even more specialized electrodes, greater skill and higher preheat and a postheat treatment.

Evaluation of Tailored Weld Metal

The earliest coated arc-welding electrodes for manual use gave a weld metal low in carbon (less than 0.10%) but high in porosity. Manganese added to the coating eliminated the porosity. Moreover, the 0.60% manganese deposit, plus silicon (reduced from silicates in the coating), gave the weld deposit a tensile strength equal to that of structural mild steel. By adding about 0.50% molybdenum, the tensile strength of the weld deposit was raised to 70,000 psi. Adding chromium raised the tensile strength even higher.

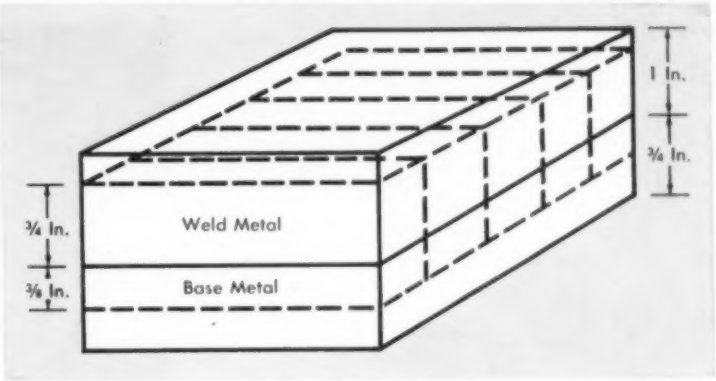


Fig. 1 – Test Coupons Cut From the Test Piece Are Indicated by Dotted Lines

However, both chromium and molybdenum additions increased the cracking tendency.

These weld deposits were low in carbon and did not respond to heat treatment. Adding carbon, by putting it in the coating, upset the desirable arc characteristics of the electrode and increased the cracking tendency. The cracking tendency can also be blamed on high hydrogen content of the weld metal, since early electrode coatings contained large amounts of moisture and hydrogen-liberating compounds.

When the low-hydrogen type of coating appeared, enough carbon could be added to raise the weld deposit to about 0.25% C without impairing weldability. With this carbon content and greater dependence on alloys, such as manganese, chromium, nickel, molybdenum and vanadium, the tensile strength was raised to about 150,000 psi.

Weld Metal Strength

Alloy additions raise the tensile strength of the weld deposit to equal that of medium or high-carbon steel base metal. Because these electrodes produce deposits low in carbon, free from cracking and porosity, and having adequate tensile strength, the idea prevails that good weld metal must be low in carbon, and many specifications limit carbon content of the weld metal.

In the past the mechanical properties of the weld deposit were matched to those of a medium-carbon alloy steel base by increasing the alloy content of the electrode coating. This was necessary because the electrode designer was unable to add carbon to the weld metal without upsetting the arc characteristics. Consequently, electrode coatings contained a higher percentage of alloys and a lower percentage of carbon than the base metal. In many applications, this high-alloy, low-carbon weld deposit has been satisfactory. However, in repair work involving medium-carbon alloy steel, this type weld metal is difficult to machine since it doesn't respond to heat treatments such as normalizing or annealing.

Because of recent developments – the advent of low-hydrogen, iron powder coatings – we now can put carbon in the weld deposit in amounts equal to or exceeding that of the principal alloy steels in use today without upsetting arc characteristics or weldability of the electrodes.

Weld Metal for High-Strength Steel

Several types of low-alloy, high-strength steel, such as 4130, 4140 and 4340, are used for aircraft components. Three weld metals were designed to match this type of base metal, which avoid hard, brittle zones in the weld area that could fail catastrophically under load. The composition of the weld metal is given in Table I, where it is compared with the base metal used in the investigation. Electrodes were prepared by

Table I – Analysis of Base and Weld Metals

Elements	4130		4140		4340	
	Base Metal	Weld Metal	Base Metal	Weld Metal	Base Metal	Weld Metal
Carbon	0.29%	0.19%	0.44%	0.38%	0.40%	0.37%
Manganese	0.84	1.35	0.89	0.95	0.73	1.09
Phosphorus	0.011	0.011	0.019	0.015	0.010	0.015
Sulphur	0.023	0.012	0.036	0.012	0.013	0.011
Silicon	0.28	0.45	0.26	0.66	0.35	0.56
Chromium	0.52	0.41	0.88	0.88	0.77	0.81
Nickel	0.43	1.33	–	–	1.76	1.87
Molybdenum	0.27	0.35	0.25	0.34	0.30	0.37

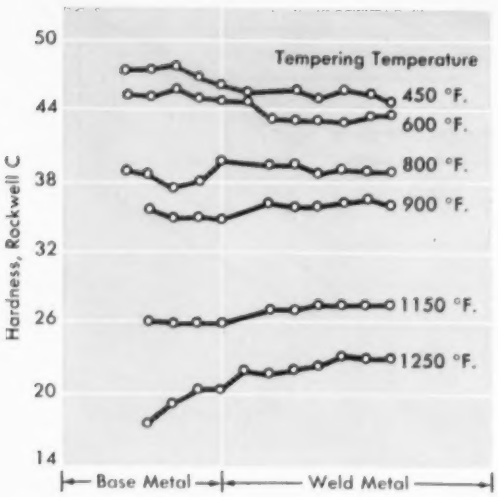


Fig. 2 – Hardness Across Junction of Heat Treated A.I.S.I. 8630 Base Metal and 4130 Weld Metal

coating mild steel core wire with low-hydrogen compositions to give the desired weld metal analysis.

Test Procedures

The base metal used for the 4130 tests was S.A.E. 8630 steel, which came into existence as an alternate for 4130 during World War II. The weld metal composition was developed for both 4130 and 8630 steels; its composition is not strictly that of 4130, but is closer to Type 8630. The 8630 and 4140 steels were rolled plate, while the 4340 was forged plate.

For a hardness survey, a 1-in. thick pad of weld metal was built up on a ¾-in. thick base plate; the base plate was in turn welded to a plate to prevent distortion. A 450° F. preheat and interpass temperature was maintained during the welding of the pad. Immediately after welding, the base plate with weld pad was cut from the restraining plate and placed in a furnace at 1400° F. and the temperature was raised to 1600° F. After normalizing, blocks were machined from the weldment to include ⅜ in. of base metal and ¾ in. of weld metal, as shown in Fig. 1. After standard base metal heat treatments, the blocks were surfaced, ground and macro-etched with 50% HCl. Hardness readings were made on the weld deposit and the base metal.

Hardness surveys across the junction between base metal and weld metal show clearly the comparative heat treating response of the weld metal

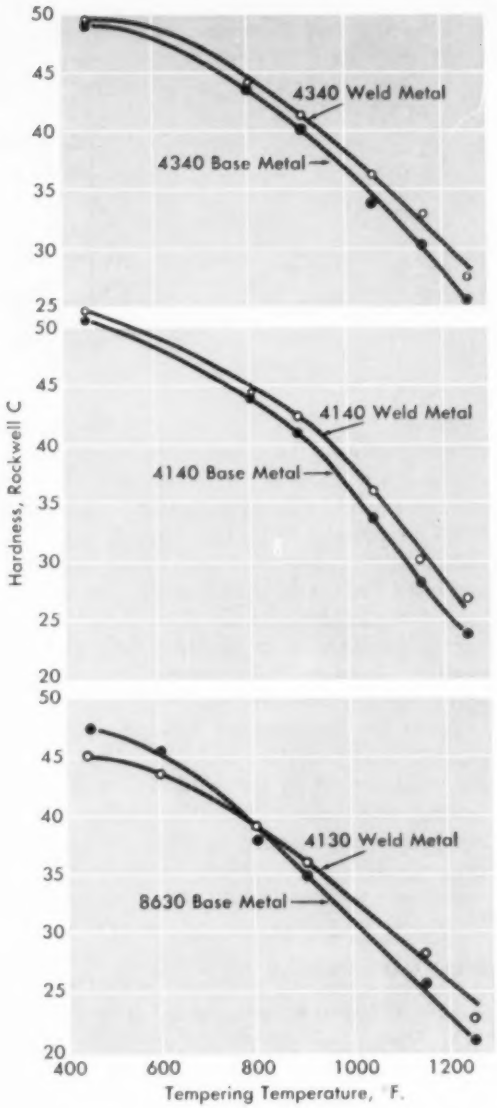


Fig. 3 – Curves Compare Hardness of Weld Metal to Base Metal Through a Range of Temperatures

and base metal. For example, the survey of 8630 steel (Fig. 2) shows that this base metal is a little harder at low tempering temperatures and a little softer at high tempering temperatures than the 4130 weld metal, but at tempering temperatures most often used for this type of steel (800 to 1100° F.), the hardness of weld metal and base metal is about the same. This relationship is also expressed graphically in the lowest set of curves assembled in Fig. 3.

There is less difference in hardness of the

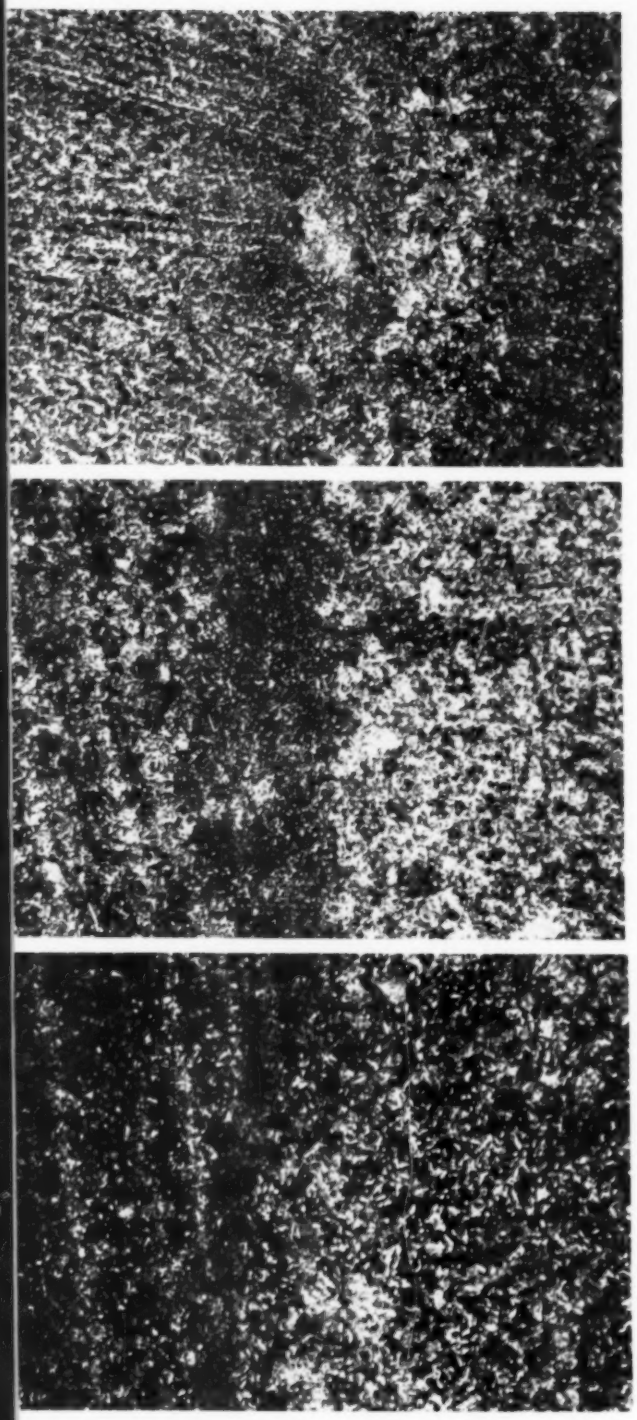


Fig. 4 – Microstructure of Junction Between Base Metal and Weld Metal. Tempered at 800° F. Base metal fills left-hand half of each micro. Top to bottom: Type 4340, 4140 and 4130 steels. 100 ×

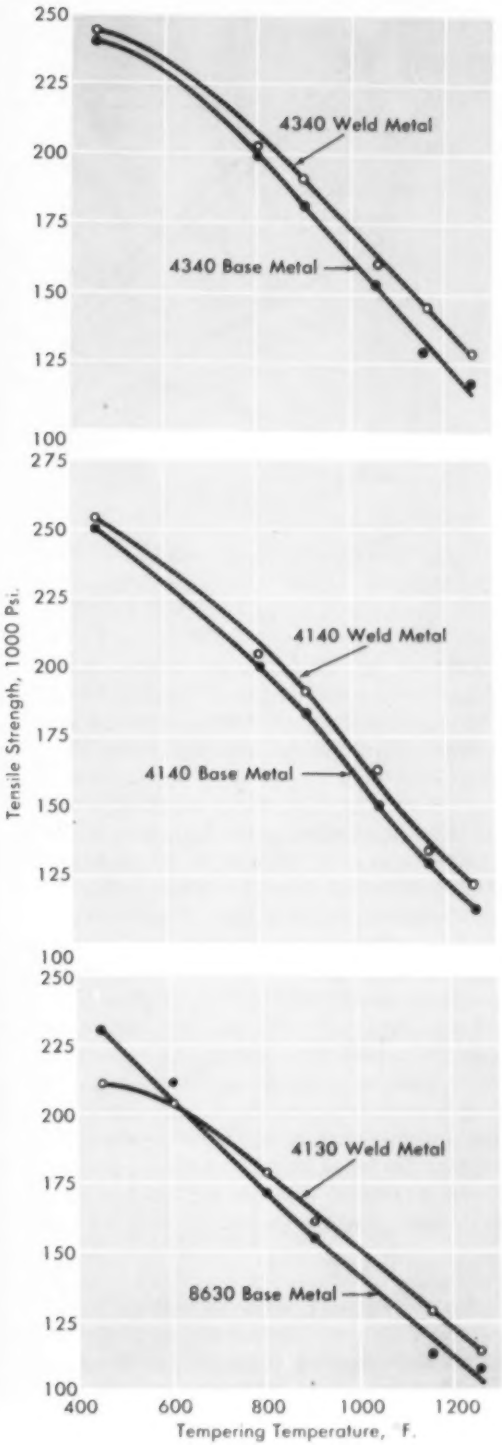


Fig. 5 – A Comparison of the Tensile Strength of Weld Metal Through a Range of Temperatures

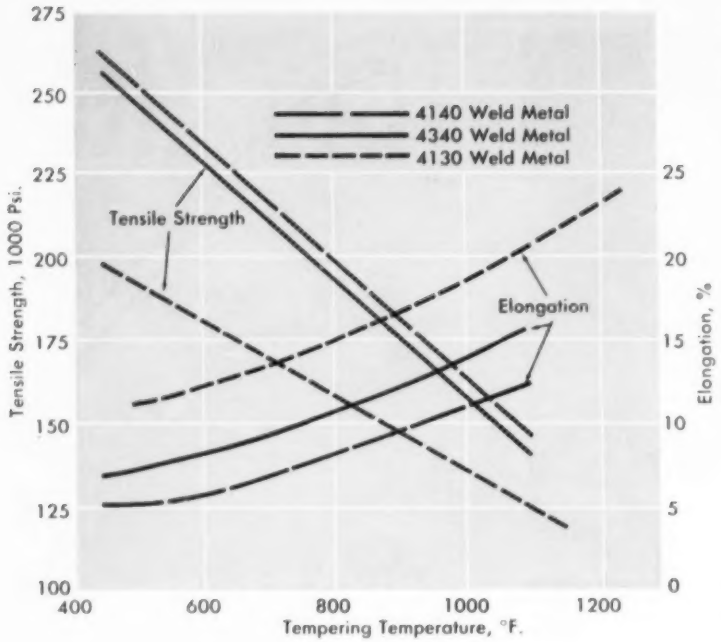


Fig. 6 — Effect of Tempering on the Tensile Strength and Elongation of 4130, 4140 and 4340 All-Weld Metal. Oil quenched from 1575° F. and tempered 4 hr.

4140 base metal and weld metal (Fig. 3) until the higher tempering ranges are reached, but at the intermediate range of 800 to 1000° F. the hardnesses of weld metal and base metal compare favorably.

The tendency for the 4130 and 4140 weld metals to be harder at the high tempering temperatures can be explained by their slightly higher alloy and lower carbon content.

The difference in hardness between base metal and weld metal is less pronounced in the 4340 grade. Figure 3 shows that the 4340 weld metal responds to heat treatment throughout the tempering range due to the similarity in analysis of base metal and weld metal.

Because all weld deposits were made under highly restraining conditions, all hardness specimens were examined at 500 × for microcracks in or near the fusion area; no cracks were observed. Typical microstructures of the junction between weld metal and base metal are shown in Fig. 4.

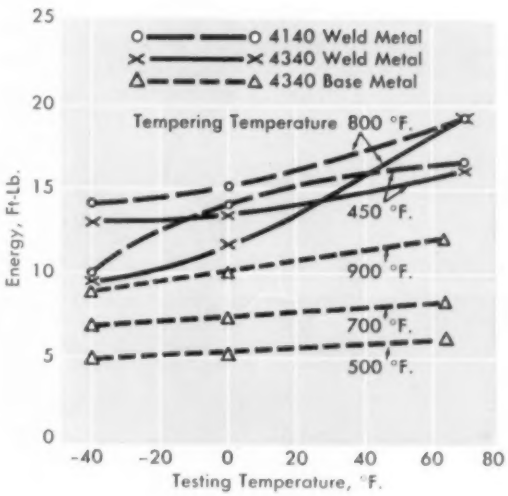


Fig. 7 — V-Notch Charpy Impact Energy Curves for 4140 and 4340 Weld Metals and 4340 Base Metal

Mechanical Properties

Tensile strength based on hardness readings of the three weld metals and base metals for different tempering temperatures is shown in Fig. 5. This graph and the preceding one show that the weld and base metals are compatible throughout the heat treating range. With the possible exception of the 8630 steel in the lower tempering ranges, all the weld metals are slightly harder than the base metals and show slightly higher tensile strength. This is because of the slight difference in analysis of these particular deposits. Figure 6 shows actual measured tensile strength and elongation of all-weld-metal tests.

Impact Properties

Standard V-notch Charpy impact bars were machined from multipass butt welds in the three

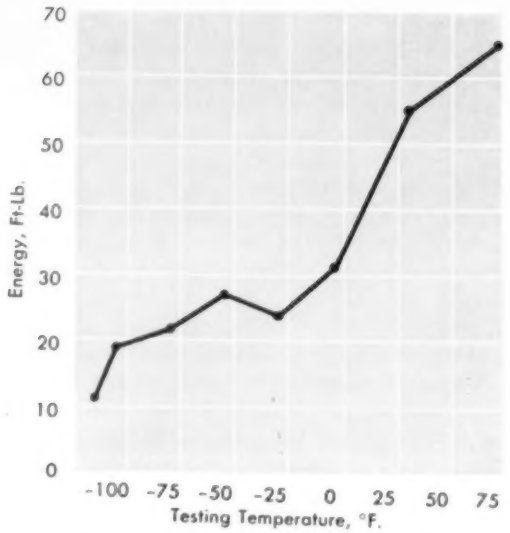


Fig. 8 – V-Notch Charpy Impact Energy Curve for 4130 Weld Metal. Oil quenched from 1550° F. and tempered at 950° F. for 12 hr.

types of base materials. Preheat and interpass temperatures were maintained at 450° and each test piece was normalized at 1600° F. immediately after welding. Impact bars were of standard 0.505-in., all-weld-metal joint design. The longitudinal axis of the specimen was normal to the longitudinal weld axis and the 45° notch was perpendicular to the finished surface of the weld and centered with reference to the root opening.

Figure 7 shows impact values obtained from the 4140 and 4340 weld metals, tempered at 450 and 800° F. While the impacts were only determined at 65, 0 and –40° F., which of course does not give a complete transition curve, the values do indicate the trend with testing temperature.

Fig. 9 – Effect of Tempering on the V-Notch Charpy Impact of 4140, 4340 and Type 502 Weld Metals. Tested at –40° F.

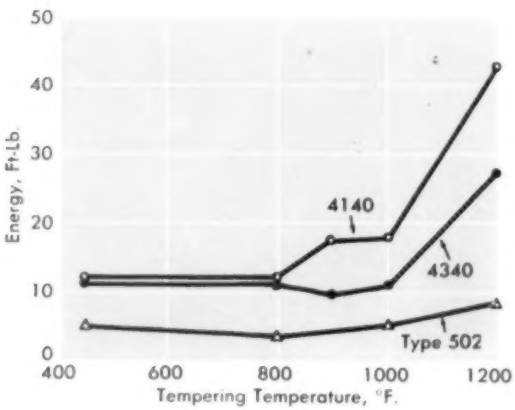


Table II – V-Notch Charpy Impact Properties of 4140, 4340 and Type 502 Weld Metals

Type	Tempering Temperature	Average Charpy Impact	
		0° F.	–40° F.
4140	450° F.	17 ft-lb.	11.5 ft-lb.
	800	17	12
	900	24	17.5
	1000	25	17.5
	1200	75	42
4340	450	15	12
	800	10	11
	900	13.5	10
	1000	18	11
	1200	45	27
502	450	8	5
	800	7	4
	900	—	—
	1000	9	5.5
	1200	14	8.3

Impact data for the 4340 base metal are also shown in Fig. 7. These results show that the 4340 base metal does not have as good impact resistance as the 4340 weld metal.

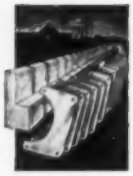
A transition curve for the 4130 weld metal tempered at 950° F. for 12 hr. is shown in Fig. 8. These results indicate that the transition temperature is not reached until near –100° F. Tests repeated on similar compositions tempered for 4 hr. show slightly higher values for the impact versus temperature data.

The effect of tempering on the Charpy impacts of the 4140, 4340 and Type 502 weld metal at –40° F. is shown in Fig. 9. Results show that the 4140 weld metal is superior to 4340 weld metal in impact resistance, and both are superior to Type 502 weld metal. Type 502 weld metal consisted of 5.39% Cr, 0.55% Mo, 0.72% Mn, 0.45% Si and 0.07% C.

Table II gives the Charpy impact values of these three weld metals tempered over the range of 450 to 1200° F. and tested at 0 and –40° F.

Significance of the Work

This new development enables the electrode designer to match the base metal with weld metal in both alloys and carbon content and produce a weldment that responds to heat treatment. Hardness surveys, tensile strength and elongation of weld metal and base metal show that the commercially available weld metal matches the base metal in hardness and tensile strength in tempering temperatures between 450 and 1250° F.



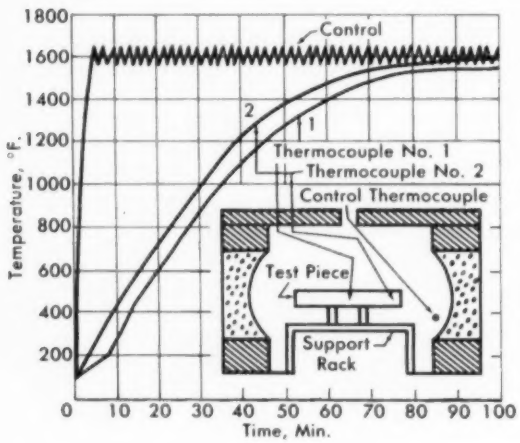
Short Runs

A Luminous Wall Furnace

A WALL that heats to red heat and above in seconds is the feature of a new furnace designed by the A. F. Holden Co., Detroit. Composed of a porous refractory lining through which a gas-air mixture can flow, this wall heats by radiation. When the fuel is lit, the brick face soaks up heat from the flame by conduction, and emits radiant energy to the charge. As the diagram illustrates, 1158 lb. of brass can be through-heated to 1600° F. in 90 min. Conductivity of the metal is good enough so that there is little temperature difference between surface and center.

Brick used for the luminous wall has two important properties: high emissivity and low conductivity. The flame heats only the brick surface; in a 6-in. thick lining, the other side will be around 150° F. High emissivity (about 0.7 between 1600 and 2000° F.) means that the brick is both a good absorber and emitter of radiant energy. This efficient heat transfer system can achieve fuel savings up to 60% as compared to similar conventional gas-fired furnaces.

Fig. 1 – Luminous Wall Furnace and Test Data. The cartridge brass charge was 5 by 26 by 30 in. in size, and weighed 1158 lb. Note the rapid rise in temperature at the wall face



Combustion Engineering Co. has installed and is operating a large 30-ft. hearth furnace built to these principles by Holden. Constructed to solution treat stainless steel tubing at 2050 to 2150° F., this furnace has cut fuel costs appreciably.

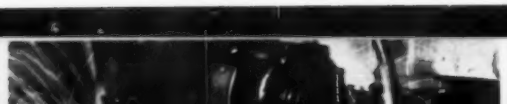
Plasma Arc Torch

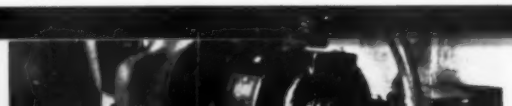
FABRICATORS working with high-temperature materials have a new tool for making shapes and applying coatings. It's the plasma arc torch, developed by Linde Co., a division of Union Carbide Corp., New York, which makes possible the use of materials virtually unworkable by conventional methods.

The torch utilizes temperatures of 15,000 to 30,000° F. to fabricate shapes by depositing successive coatings on a spinning mandrel, as illustrated in Fig. 1. The mandrel is dissolved leaving the part unaffected. In this instance, tungsten (which has a melting point above 6000° F.) is drawn into the torch in powder form. It melts and is carried out of the torch nozzle by a continuous flow of inert gases. The metal particles, still in a liquid or plastic state, strike the mandrel at high speed and are at once cooled by sprays of carbon dioxide gas.

Baking Operation – At this stage, the tungsten has a density of 94 to 95%, modulus of rupture of 44,000 psi. and Young's modulus of 22×10^6 psi. After the mandrel is removed (an acid bath is used which attacks only the brass), the shape is fired in an inert atmosphere furnace for 2 hr. at about 2500° F. After firing, density is increased to 97 to 98%, modulus of rupture to 57,000 psi. and Young's modulus to 34×10^6 psi. The volumetric and linear shrinkages upon firing are 2.2% and 0.7%, respectively – considered to be low compared with those obtained with tungsten formed by other methods.

Coatings Are Unique – Coatings made with





the torch are quite different from those made by other processes. They have excellent bond to almost any base material, including some reinforced plastics, graphites and carbons. Bonds appear to be chemical and mechanical in character and are stronger than those obtained by electroplating, vapor deposition or metal spray. The coatings are dense, usually laminar in structure, and may be finished to below 10 micro-in. One application is coating of graphite rocket nozzles with tungsten. A typical nozzle is shown in Fig. 2, lower left.

Areas of Application – As far as is known, most inorganic materials that melt without decomposing can be used. These include:

- Refractory metals, such as tungsten, tantalum, molybdenum, columbium and rhenium.
- Refractory metal compounds, including borides of Zr, W, Cb, Ta, Ti and Cr; carbides of Cb, Hf, Ta, Zr, Ti, W, V; oxides of Th, Hf, Mg, Zr, Ce and Al.
- Noble metals – platinum, palladium and others in this group and their alloys.

In addition to rocket and missile parts of pure tungsten or tungsten-coated graphite, the torch is used to produce high-density tungsten crucibles for metallurgical purposes, special parts for nuclear work, sensitive electrical contacts, electronic components, and X-ray targets of superior density.

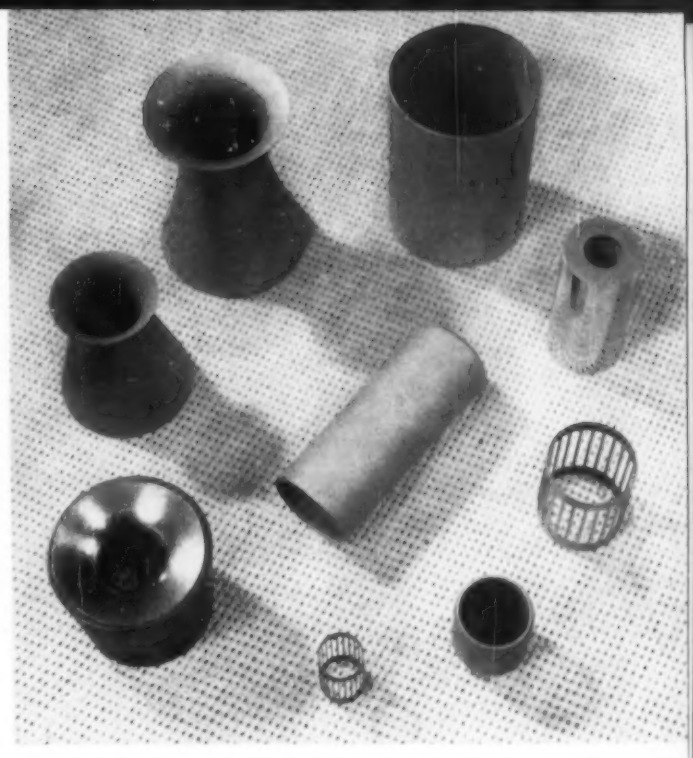


Fig. 2 – Parts Made by Plasma Arc Torch. Bottom left is a rocket nozzle made of graphite and coated with tungsten. Above it are two rocket nozzle liners made of tungsten. Center and right, are tungsten and tungsten-coated tubes. Bottom right is a crucible of tungsten. The open-work parts are grid cages of high-density tungsten for electronic vacuum tubes

Fig. 1 – Nozzle Liner for Rocket Engine Is Formed by Depositing Pure Tungsten on Brass Mandrel



In electronic applications, the method is used to apply boron coatings to nickel parts used for electron suppression. Coatings of nickel containing barium and strontium carbonates have been applied to molybdenum cathode cups to serve as low-temperature emitters. Coatings of tungsten on contact points show promise both functionally and economically.

Another promising area of application is making refractory parts, such as silica crucibles. Still another is permanent molds for high-temperature service. An example: A molybdenum mold is coated with tungsten for use in casting a highly radioactive metal rod. Thermocouples and thermocouple wells coated with platinum and palladium have performed exceptionally well. Another application is coating Inconel screens with manganese oxides for the catalytic decompositions of hydrogen peroxide.





You Can Do More With CO_2 Welding

STAFF REPORT

Improvements in automatic and semi-automatic welding heads, and refinements in shielding techniques add to the versatility of the process. With a reactor in the circuit, good overhead and vertical-up welds are possible. In addition to its shielding function, CO_2 gas raises the temperature of molten weld metal and deepens penetration. (K1d, 1-52)

IT'S TIME to take another look at CO_2 welding. Refinements enable the process to handle many fabricating operations more efficiently. These include:

- Better arc control: less spatter; vertical and overhead welding are possible.
- More efficient welding heads: improved shielding; use of air cooling.
- Tougher, more versatile wire feed units that operate at higher speeds and carry more load.
- Better understanding of the metallurgical reactions. Result: Wire chemistry has been tailored to fit the process.
- More efficient welding techniques permit a wider range of applications.

A glance at the photographs above (Fig. 1 and 2) shows what a stable arc can accomplish: By placing a reactance device in the electrical circuit, engineers at Fisher Body Div., General Motors Corp., have greatly improved the operating characteristics of the process. Almost all equipment manufacturers have explored this area of arc stability and now supply welding reactor equipment.

Improved Welding Guns

Several manufacturers have taken a second look at their welding guns. One believes that a small amount of air is carried by the electrode wire into the welding head. By blowing CO_2 gas over the wire (by means of a bleedback) before it emerges from the gun nozzle, he removes the air from the stream. Another manufacturer is producing an air cooled welding gun and a

Fig. 1 (Left, Opposite) – Although This CO_2 Unit Puts on a Spectacular Pyrotechnic Display, Spatter Condition Is Far From Pleasing. It's inefficient, clogs working parts and produces an unattractive weld.

Fig. 2 (Right, Opposite) – When a Reactive Device Is Added to the Welding Circuit, Better and More Efficient Arc Characteristics Are Obtained. (Courtesy Fisher Body Div., General Motors Corp.)



Fig. 3 – An Overhead Fillet Weld Is Easily Made When a Reactance Device Is Connected to the Welding Circuit. This particular semi-automatic gun contains a gas bleedback to remove air from the wire surface. (Courtesy Westinghouse Electric Corp.)

refined wire feed unit containing two pairs of drive rolls and a heavier motor.

Welding wires are being reappraised. Additions of silicon and aluminum have improved wire chemistry. Several laboratories are experimenting with flattened wire and corrugated wire which enable the electrode to fill wider gaps.

Power Source

The power source is the heart of the CO_2 welding operation and many refinements are being made in this area. The process requires positive control over arc voltage (voltage influences the arc length). The arc needs a variable current supply to maintain constant wire burnoff. The power supply will determine the amplitude of current change when short circuits occur. The power source should also be capable of compensating for power line fluctuation to control arc length.

Constant Voltage Unit – This type of unit maintains a constant voltage for absolute control of the arc. Voltage is preset and remains relatively constant in spite of current changes. Constant voltage systems are available in both motor generator and rectifier units. The voltage drop in the arc stream is high. A short stickout – ½ in. or less – is most effective. (Stickout refers to the distance from the tip of the contact tube to the tip of the electrode).

Welding Reactor – an Innovation

The welding reactor mentioned previously is a new addition to the welding circuit. It improves the operational characteristics of the process by providing a more stable, more versatile arc. This means that lower "heat settings" are available and all-position welding is now possible. Vertical-up and vertical-down welds can be made with ease. Good overhead welds are also obtained. The small amount of spatter evolved in the overhead position (Fig. 3) should appeal to welding operators.

The reactor appears to be most suitable on applications involving light-gage material welded at low and medium welding speeds using small-diameter wire. At high speeds the dynamic reactor appears to retard the current response when a quick response is required.

How It Works – As the tip of the electrode becomes molten, it projects a globule onto the plate surface. The globule shorts the arc and signals for more current. Ordinarily this current reacts so quickly that a surge of five to ten times the normal rate causes the globule to blow out of the fusion zone. The dynamic reactor acts to retard this instantaneous response.

Since many fabricators have a big stake in welding research programs, it is not surprising that their engineers would independently develop new concepts. At Fisher Body Div., General Motors Corp., a group working under Robert E. Allan perfected one type of welding reactor. As Mr. Allan points out, "Spatter causes trouble; it damages cogs, linkages, and chain conveyers, and so we just had to find a way to solve the problem. Thomas Shearer and Arthur Hessler discovered that a reactor, working on a self-induction principle will subdue current surges and minimize spatter." Note the change in spatter condition without the reactor in the circuit (Fig. 1) and with the reactor plugged in (Fig. 2).

Wire Feed Mechanism

There are two approaches to the wire feed problem. One involves pulling the wire from a reel by means of wire feed drive rolls located at the gun itself. The other involves a pusher-type unit with the wire feed drive rolls located adja-

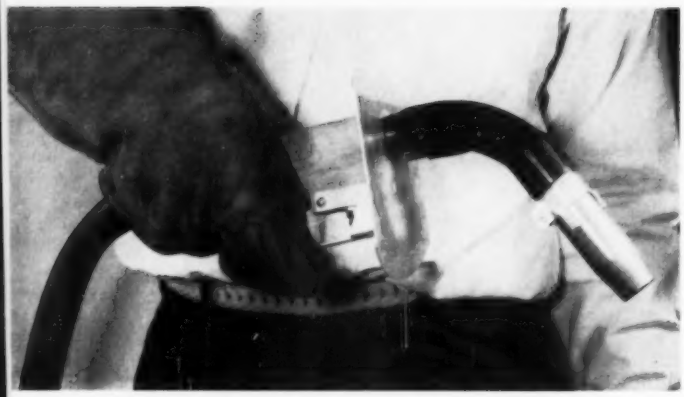


Fig. 4 – A Recently Introduced Air Cooled Welding Gun. (Courtesy Hobart Brothers Co.)

cent to the wire coil unit. The latter unit pushes the wire electrode through a connecting cable into the gun. The puller unit appears to be gaining favor since, for one thing, it eliminates the possibility of buckling in the connecting cable. With this unit, the wire reel can be located at a greater distance from the welding site. Wire size can be critical below 1/16 in. diameter.

When wire is pulled from a distance and at high speed, it may not always pull at an even rate of speed. J. W. Holzman, assistant chief engineer of Parish Pressed Steel Div., Dana Corp., Reading, Pa., took a look at this problem: "The single drive roll and spring loaded pressure roll did not provide enough traction; the wire would slip. So we increased the serrations, but these serrations gouged out the wire to such an extent that the wire behaved like a file, wearing out contact tubes.

"We asked several manufacturers of welding machines to supply us with a unit containing two pairs of drive rolls and a heavier drive motor. We were quick to get it. In addition the serrations were replaced by smooth trapezoidal cross-section drive roll grooves. These grooves grip the wire and prevent slippage."

Importance of Gas Nozzle

The welding nozzle should have an efficient cooling system. Essentially, two schools of thought prevail. There are those who consider that water cooling is necessary; another group feels that air cooling is satisfactory and desirable. If present indications are reliable, the water cooled nozzles are in for some real competition. As one fabricator put it, "We are reaching a point where we have to be plumbers as well as welders and that isn't good." A short circuit would occasionally burn a hole through the water jacket, or the O-ring seals would leak.

These incidents occurred frequently enough to be irritating and it was not unnatural that the idea of air cooling was suggested. One manufacturer modified an air cooled, hard facing gun. He increased the copper in the nozzle area to improve heat dissipation. Figure 4 is an example of an air cooled gun. Perhaps it is a misnomer to call this an air cooled gun since there are no fins or air supply surrounding the nozzle. Actually it is cooled by the atmosphere surrounding it.

There are many innovations on the water cooled and air cooled themes. In many instances they satisfy specific shop requirements. For example, several welding head designs maintain the gas shielding externally with the CO_2 nozzle at the leading end of the welding head. To save money one fabricator uses an expendable gas nozzle made out of 1-in. copper pipe, cut to size, and friction fitted. For a mere outlay of 30¢ he has replaced a machined nozzle costing several dollars.

Minimizing Spatter

Nozzle spatter can be a serious problem. In a short arc the molten globules ejected to the side are either absorbed by the weld or rebound into space; however, some of the particles moving vertically down eventually rebound, attaching themselves to the nozzle. This collection of spatter will eventually prevent the efficient flow of CO_2 shielding gas. The period of operation before excessive spatter accumulates is substantially increased by tilting the gun at an angle to the weld joint. If a reactor is placed in series with the power source, the surge of current will be less and the explosion of the molten globules will also be much less severe and spatter will virtually disappear.

If the transfer takes place when the arc is long, rather than very short, it is doubtful that any good can be obtained from a reactor. In this instance, there are no short circuits. The large molten drops are pushed to the side by forces within the arc stream. These forces prevent the drops from being projected axially, and in consequence the drops form spatter which can adhere to the work or to the gas nozzle.

Gas Flow

The effectiveness of gas flow depends upon the length of the nonturbulent stream extending from the nozzle and also depends upon the stiff-

ness of the stream. A glance at Fig. 5 will show that the length of the nonturbulent stream is not critical, since it will extend into the weld puddle. "Stiffness" enters into the picture only when heavy drafts of air may be encountered. Carbon dioxide gas is slightly "stiffer" than argon.

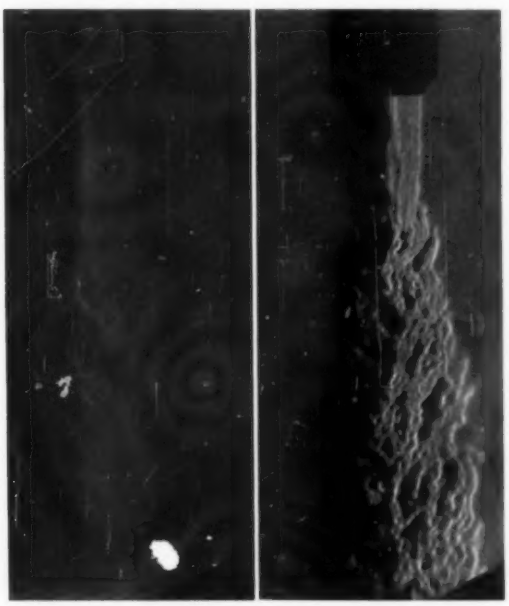
Nozzle Spacing – According to Edward J. Vogel, Liquid Carbonic Div., General Dynamics Corp., space from the end of the concentric gas nozzle to the workpiece should measure ½ to ¾ in. For a side gas shield, the nozzle-to-work distance can be greater than for the above type. He points out that the distance will depend upon welding conditions, because excessive space reduces the effectiveness of the gas shield.

Inadequate shielding will show itself in excessive spatter, porosity and weld discoloration. A long arc results in loss of manganese and silicon and consequent loss of strength and if the porosity is severe, ductility will drop. On the other hand excessive shielding – a very high flow rate, turbulent enough to entrain air in the arc column – will cause porosity, and a rough weld shape. Correct space and gas flow will depend upon the application.

Chemical Activity of CO_2

Carbon dioxide gas reacts with the molten metal by dissociating as the temperature increases. The temperature of the welding arc is about 14,000° F., and within the arc column complete dissociation occurs. Carbon monoxide and oxygen form. Some of this oxygen will oxidize the molten metal. Carbon monoxide also dissociates but to a much smaller extent than carbon dioxide. Carbon dioxide need not be dissociated in order to oxidize metal. For ex-

Fig. 5 – Flow of Gas From Welding Gun. Argon on the left and carbon dioxide on the right. Gas flow 60 cu.ft. per hr. (Courtesy Air Reduction Sales Co.)



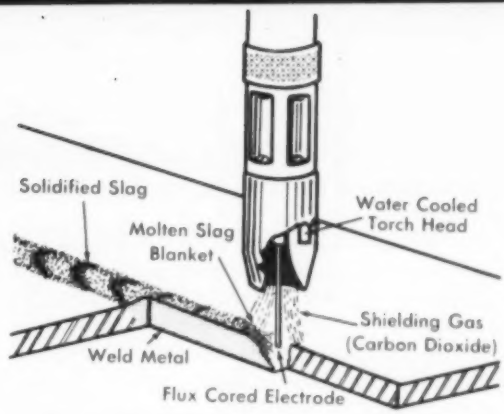


Fig. 6 – In This Flux-Cored Electrode, Steel Tubing Is Pinched Together and Contains Granular Flux Filler Material. Carbon dioxide gas shield surrounds the electrode. (Courtesy National Cylinder Gas Div., Chemetron Corp.)

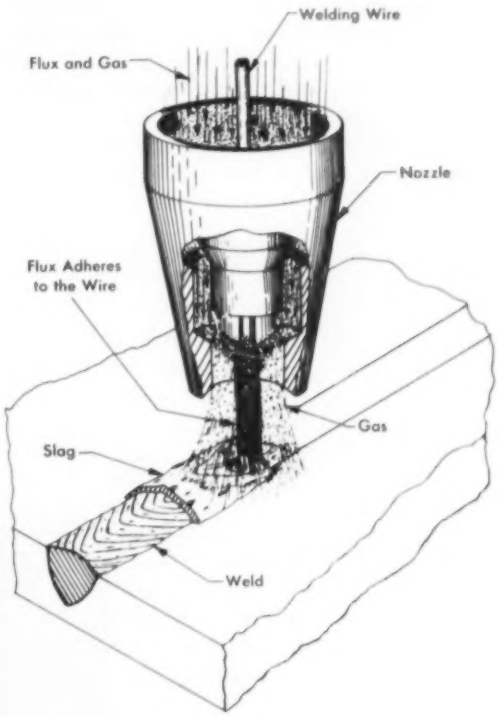


Fig. 7 – Magnetic Field Surrounding the Welding Wire Attracts the Flux to the Wire. Simultaneously CO_2 shielding gas emerges from the nozzle. (Courtesy Linde Co.)

ample, carbon dioxide can react directly with iron, as shown in the following equation, to form iron oxide:

$$Fe\,(l) + CO_2\,(g) \rightarrow FeO\,(l) + CO\,(g)$$

Since equilibrium does not exist in the arc, it is not known whether the thermal dissociation or the reaction of Fe and CO_2 produces the larger quantity of FeO. The fact that CO_2 gives an oxidizing effect has been known for many years. In the absence of deoxidizers such as silicon and aluminum, the iron oxide can combine with the carbon to form carbon monoxide which, if trapped, would form porosity in the weld metal.

Knowing a mechanism and understanding it are two different matters. It has only recently been recognized that only a small percentage of oxygen moves into the arc stream. Robert Keller, chief engineer, Welding Products Div., A. O. Smith Corp., finds that if a deoxidant is added the free oxygen will combine with it and form "minute islands of slag which float to the surface of the molten pool of metal". He is also convinced that most of the uncombined carbon monoxide, in the outer fringes of the molten pool, combines with oxygen to form carbon dioxide.

Gilbert R. Rothschild, assistant director of metallurgical research, Air Reduction Co., has established that "for both carbon and stainless steel, the amount of manganese and silicon lost through oxidation in a carbon dioxide shield varies inversely with the arc length. Reduced loss at short length may be due to the decrease in the available reaction time [between gas and liquid] or the replacement of the oxidants by the vapor deep in the weld pool".

Inert gases, such as argon, do not react and therefore they do not contribute to the heat in the molten pool. The various oxidation reactions resulting from dissociated carbon dioxide, on the other hand, help to raise the temperature of the molten metal and increase the depth of penetration of the electrode.

Carbon Pickup – Mr. Rothschild notes that in welding carbon steel, a slight decrease in carbon content occurs, and in stainless steel the carbon content increases slightly. He states that "part of the increased carbon in stainless steel is detected in massive complex carbides".

Julian Carey, chief welding engineer, York Div., Borg Warner Corp., has noticed that low-carbon steels (0.10% C) show an increase in carbon of several points, and higher carbon steels (0.25% C) show a similar decrease in carbon. He believes that somewhere in between (approximately 0.15% C) the carbon dioxide arc is in equilibrium with a steel of that carbon content.



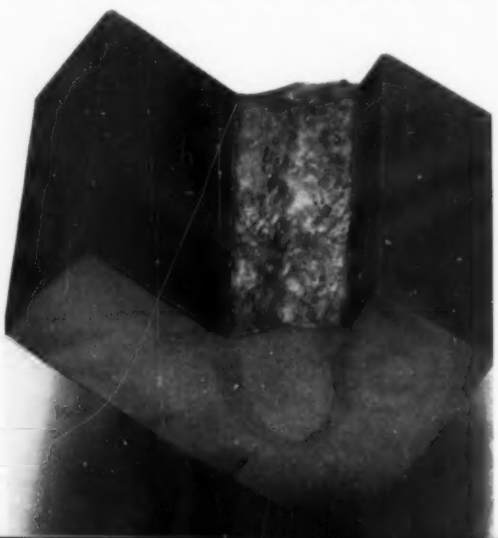
Fig. 8 – Lap Welding Automobile Frame Side Rails and Cross Sections. Speeds up to 120 in. per min. are achieved. Welding units are located on a mezzanine floor. Weight of welding cable is minimized by suspending it from the mezzanine floor. (Courtesy Parish Pressed Steel Div., Dana Corp.)

Properties of CO_2 Weldments

Mechanical properties of CO_2 weldments compare favorably with those made by other welding processes. There seems to be full agreement among users that strength, ductility and impact properties of carbon steel welded with CO_2 shielding gas are comparable to those obtained with argon. Tensile properties of stainless weldments are also reported to be virtually identical for both CO_2 and argon shielding. However, impact strengths obtained with CO_2 are inferior.

(*Continued on p.* 170)

Fig. 9 – This Fillet Weld Made in Flat Position on ⅜-In. Plate Shows the Deep Penetrating Quality of the CO_2 Welding Process. The weld surface is reasonably smooth and free from undercuts. (Courtesy A. O. Smith Corp.)



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When heat treating requirements are not in the least critical, there are probably cheaper ways you can handle them than in salt. But when highly precise results must be obtained—economically, with a minimum of labor cost—then salt baths offer possibilities that cannot be overlooked.

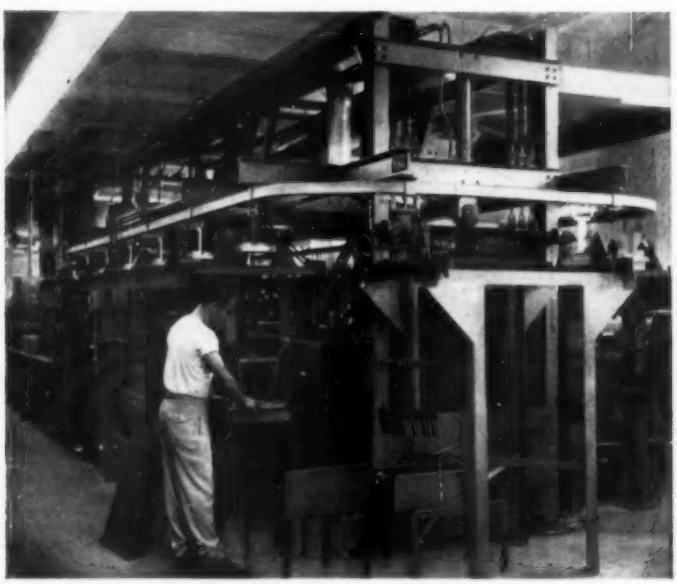
It is now common practice to handle on a salt bath mass-production basis, heat treating so ultra-precise that it may have been regarded as a laboratory method not many years ago.

Moreover, extending far beyond their obvious advantages in hardening steels, salt baths have "come of age" in many different directions.

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LEADERS IN SALT BATH PROGRESS SINCE 1936

Personal Mention

Ralph A. Schaefer has been named director of the newly established research and development department of the Bunting Brass and Bronze Co., Toledo, Ohio. Dr. Schaefer comes to Toledo from the Cleveland Graphite Bronze Div. of Clevite Corp. where he was technical advisor to the president.

Theodore B. Wilk, sales representative for the A. F. Holden Co., Detroit, has been assigned to the firm's industrial sales organization in northern Ohio and western Pennsylvania as district manager.

Gilbert R. Semans has been appointed chief steel metallurgist of A. M. Byers Co., Pittsburgh. Before joining Byers, he was director of metallurgy at Jessop Steel Co. and affiliated with Universal-Cyclops Steel Corp. and Kennametal, Inc.

William L. Fink, chief of Alcoa Research Laboratories' physical metallurgy division since 1943, has been promoted to the newly created position of scientific coordinator for the Laboratories in New Kensington, Pa. The physical metallurgy division's rapid growth has necessitated the creation of an additional unit called the fabricating metallurgy division. Chief of the physical metallurgical division is **H. Y. Hunsicker**, formerly assistant chief of ARL's Cleveland division. **J. A. Nock, Jr.**, formerly assistant chief of physical metallurgy, has become chief of the new division while **J. P. Lyle**, a former research metallurgist, has been promoted to assistant chief.

Three new staff appointments were recently announced by Pyromet Co., South San Francisco, Calif. **A. W. Land**, who has been with the firm since its formation in 1950, has assumed duties as brazing engineer and plant engineer while **Arndt C. Fortlage**, former production metallurgist, has become production manager. **Robert C. Bertossa** has joined the company as technical director, after resigning as senior research metallurgist at Stanford Research Institute.

Robert Knight is currently sales service manager for the Johnston and Funk Metallurgical Corp. in Wooster, Ohio. He was formerly employed for more than eight years by Crucible Steel Co. of America in Syracuse, N. Y., as customer contact metallurgist and more recently as supervisor of the company's production laboratory.

C. B. Griffith, formerly with Cramet, Inc., Chattanooga, Tenn., is now supervisor of physical chemistry at the Republic Steel Research Center in Independence, Ohio.

Rolland R. La Pelle has been assigned to the laboratory operation and service unit of the materials and process staff of the Boeing Airplane Co. development center in Seattle, Wash. He was manager of sales and engineering for Heat and Control, Inc., San Francisco, and before that manager of the industrial heating division of Westinghouse Electric Corp. on the West Coast prior to joining Boeing.

Frank A. Fazzalari has left the titanium division, central alloy district, of Republic Steel Corp., to accept a post as applications engineer in the industrial process control group of the automation division of International Business Machines Corp., New York.

Edward L. Bedell is currently working for Allis-Chalmers Mfg. Co., Milwaukee, Wis., in the research department.

Ernest K. Booth has resigned as section chief, materials engineering and development, Avro Aircraft Ltd., Molton, Ont., to accept a position with the stratos division of Fairchild Engine and Airplane Corp., Bay Shore, L. I., N. Y., as senior metallurgist.

E. E. Billinghurst, Jr., formerly a staff metallurgist for Aluminum Co. of America working at the Lafayette, Pa., plant, is now a research metallurgist with National Cash Register Co., Dayton, Ohio, working on development of ferromagnetic computor components.

Mario Tama, since 1942 secretary and research engineer of Ajax Engineering Corp., Trenton, N. J., has been elected vice-president of the organization.

Hans J. Heine, until recently associated with the Metals Engineering Institute and as technical director of the publication development division of American Society for Metals, has left ASM to take up a position as technical director for the Malleable Founders Society at their headquarters in Cleveland.

Laurence Pellier has joined the staff of the research laboratory of the International Nickel Co., Inc., at Bayonne, N. J., as a member of the laboratory's physics section. Mrs. Pellier will study the microstructural changes which occur in jet engines and other high-temperature alloys that are subjected to high stresses at high temperatures.

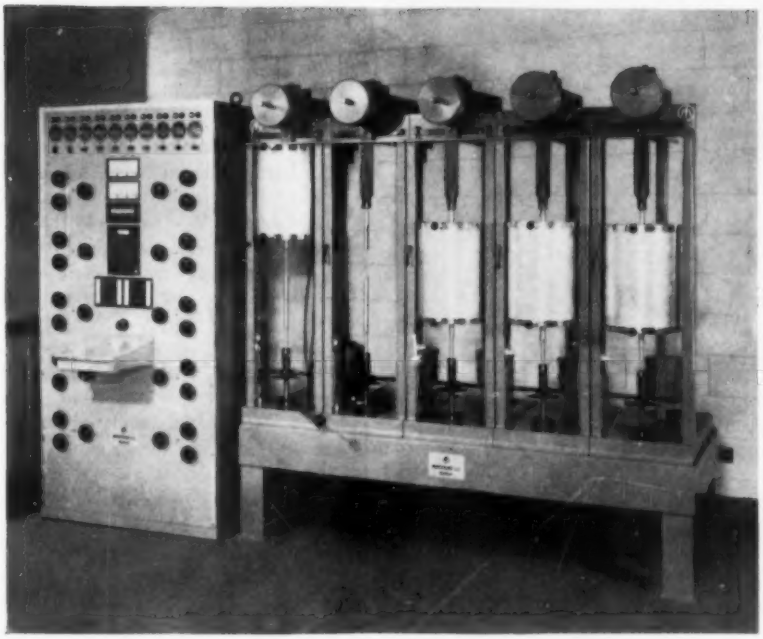
John E. Hockett recently received a doctor of engineering degree in metallurgy from the University of California. Dr. Hockett is currently a staff member of the Los Alamos Scientific Laboratory in the metallurgical research group.

F. C. Langenberg, formerly supervisor of the pyrometallurgy section in the central research laboratory of Crucible Steel Co. of America, Pittsburgh, has been appointed a material and process engineer. He came to Crucible in 1955 as supervisor of metallurgy at the research laboratory in Pittsburgh.

Walter C. Troy has left his position as senior research engineer at Malleable Research & Development Foundation in Granville, Ohio, to accept a post as research staff engineer in the powder metallurgy department of Solar Aircraft Co., San Diego, Calif.

Roland J. Berkol was recently promoted to advertising and public relations manager for the Jones & Laughlin Steel Corp. stainless and strip division in Detroit. Prior to joining the division in 1954, he was connected with Atlas Steels Ltd., Welland, Ont., and Armco Steel Corp., Baltimore.

Harold E. Barnum has been assigned to the post of assistant manager, foundry division, for Vanadium Corp. of America's Detroit office.

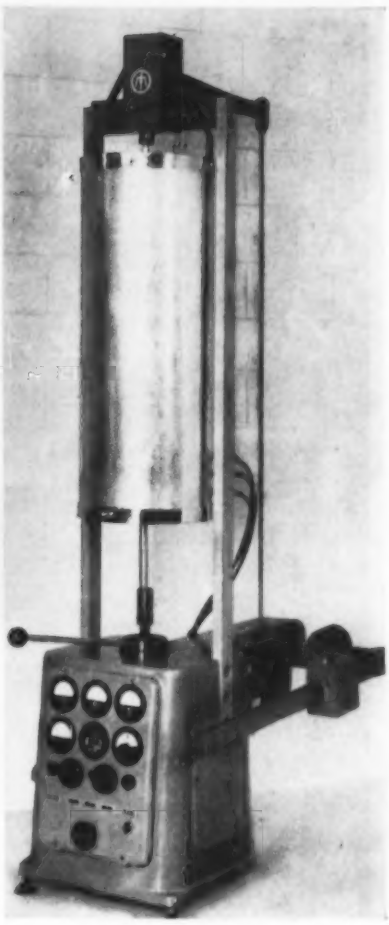


Above: The control cabinet shown has regulating and measuring equipment suitable for 10 furnaces. The furnaces are independent from one another. Equipment of this type is desirable for research and original explorations.

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Creep Strain Testers

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Ten samples strung end to end are accommodated by this tester. Its low cost per specimen makes large volume routine testing possible.

Creep testing has in many instances progressed from an experimental to a routine basis in the past few years. The physical properties of a steel which is to be used at normal temperatures can be determined by a simple test, because the properties of steels do not change with time at ordinary temperatures. However, the designers now want materials which will endure high temperatures under load for long time periods. Such materials are needed to obtain greater efficiency in modern and future engines, turbines and other machinery. We have the problem of testing many possible materials at many possible loads at many different temperatures over many different time periods. The question arises—Is it possible to test for a short period, say 48 hours and extrapolate the results for longer times? Unfortunately, in most cases the answer is no, if temperatures over about 400° C. (720° F.) are under consideration. Test periods of 1,000 to 10,000 hours are common and tests up to 100,000 hours (over 10 years) are being carried out.

It is obvious that a large number of single sample testers would be required for a long term test program on even a few steels.

Mohr & Federhaff, in cooperation with some of the most advanced creep test laboratories in Europe, have arrived at the following solution: A few individual or battery type testers for individual samples should be used for research and experimental work with the balance of the long term testing being handled by multiple testers accommodating 10 samples fastened end to end in one furnace and loading system. This has made large scale testing possible.

We believe an examination of the problem indicates that the combination of a few single unit creep testers with several multiple testers affords the most satisfactory means of obtaining voluminous creep data.

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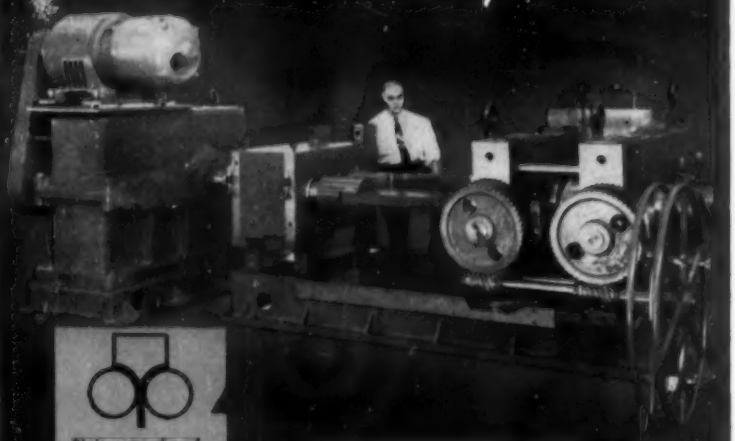
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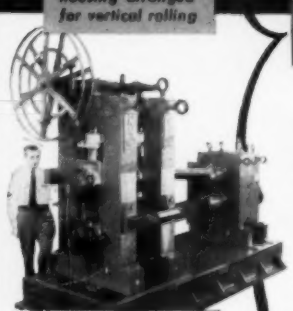
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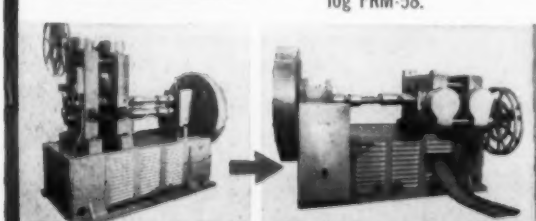




Pinion stand and housing quickly converted for conventional, horizontal rolling.

Here is outstanding flexibility for the metallurgical laboratory or production. This Fenn Dual-Purpose Rolling Mill can be used for both powder metallurgy and strip rolling. Combines all the precision features of other Fenn mills, yet, this Fenn Convertible Rolling Mill is literally two mills in one... ideal for application wherever space and capital are limited. By simple movement of pinion stand and roll housing, it quickly converts for either vertical or horizontal rolling. Mill featured is a Model V4-126 Two-High/Four-High Combination Mill with 12" rolls, 40 HP variable speed AC drive. Write for complete information and Fenn catalog FRM-58.

* patent applied for



The inherent design of Fenn Rolling Mills permits all sizes to be supplied with the Convertible feature. Illustrated is a Series 6 Convertible Mill.

THE FENN MANUFACTURING COMPANY • 501 FENN ROAD • NEWINGTON, CONN.

Personals . . .

Norman E. Bateson has been named director of research and development for Pullman-Standard Car Mfg. Co., Chicago. Mr. Bateson, who has been deputy director of the research department at Hammond, Ind., since 1953, succeeds **O. C. Maier** who recently resigned to accept a position as associate dean of engineering at the University of Massachusetts, Amherst, Mass.

Gerard E. Claussen has joined Arcrods Corp., Sparrows Point, Md., a wholly-owned subsidiary of Air Reduction Co., Inc., as director of research and welding engineering. Prior to assuming his present position, he was affiliated with Reid-Avery Co., Baltimore, and the Union Carbide Corp.

George D. Stutzman has been appointed manager of the newly created conversion sales department of Latrobe Steel Co., Latrobe, Pa., moving up from the post of assistant manager of sales service.

Archie L. Spratt has been appointed director of research and engineering for the Metal Forming Corp. division of Vanadium-Alloys Steel Company in Elkhart, Ind. The new director was formerly a metallurgical engineer in the customer service department at Vanadium-Alloys' main office in Latrobe, Pa.

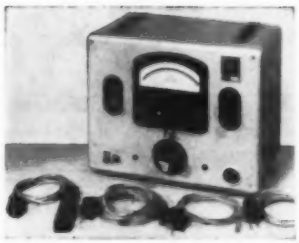
Samuel Rothstein, formerly consulting engineer at the Fairchild Camera & Instrument Corp. in Long Island, N. Y., recently joined the technical staff of Greenwich Engineering Div. of the American Machine & Foundry Co., as head of its metallurgical and materials group.

P. J. Chadwick has been assigned as branch manager in Knoxville, Tenn., for the National Cylinder Gas Div. of Chemetron Corp. A member of the company for the past five years, he has been employed in the Chattanooga office.

William F. Davenport has been appointed metallurgical engineer in the Los Angeles district sales office of Universal-Cyclops Steel Corp., Bridgeville, Pa. Before coming to Universal-Cyclops, he was associated with Chrysler Corp.

MAGNAFLUX CORPORATION

offers you industry's broadest range of testing systems and equipment for nondestructive testing

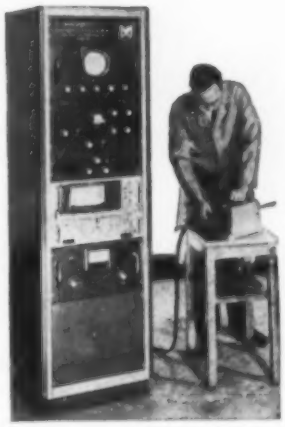


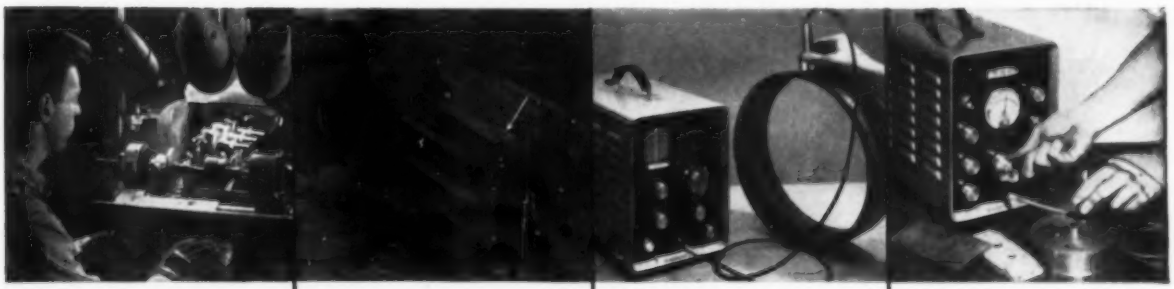
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Detects seams, cracks, concentrated porosity, inclusions, stringers, laps and splits automatically Finds diameter variation, embrittled areas and scale. Provides completely automatic, high speed production of copper tubing. Inspects aluminum rod for voids, scale and other conditions which cause trouble in drawing or final wire. Designed for heavy industrial use.



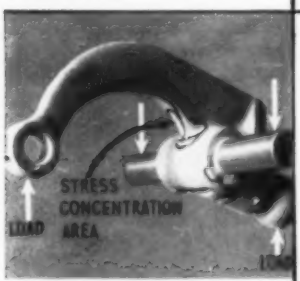


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Chiefly for nonmagnetics for defects open to the surface. Fluorescent penetrant, black light. Practically any volume and speed required. Controlled sensitivity. Also portable kits and leak tests.

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Ultrasonically measures thickness from one side only in tank walls, cast, formed or welded products, etc. Also diacovers sub-surface defects, laminations and lack of bond.

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Electronic eddy current instruments. Numerous types with industry-wide application. Conductivity, magnetic fields, dimension, hardness, alloy, coating thickness, cracks, etc.



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Brittle coating stress analysis tool. Helps in designing stronger parts with less weight. Shows stress distribution, direction, and stress level over entire part.

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Low cost, spray-on red dye penetrant inspection for maintenance or sampling on small surface areas.

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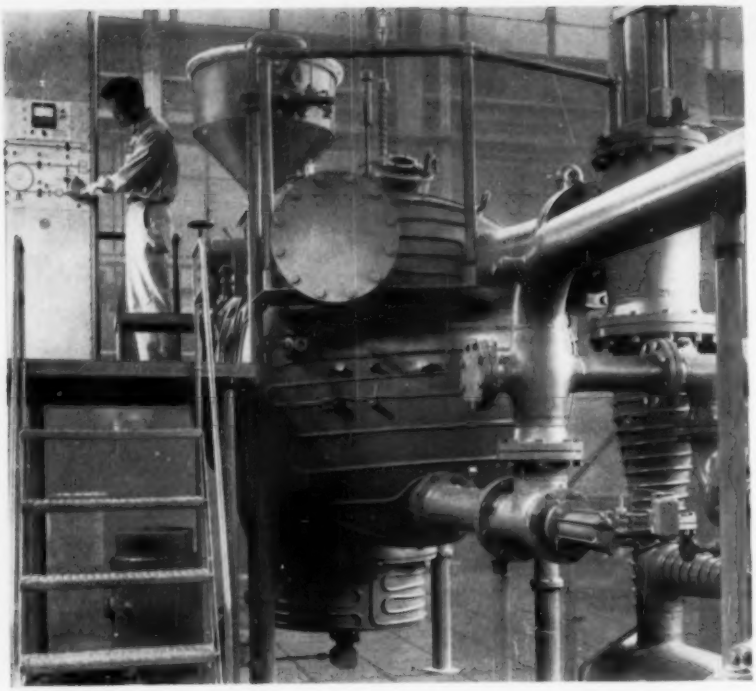
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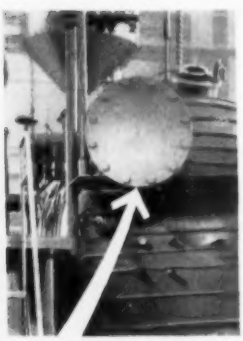
KEEP UP TO DATE ON M TEST SYSTEMS—

The methods and latest developments. Call in a Magnaflux Engineer . . . or write for copy of "Seeing Isn't Always Believing" containing briefed information on all Magnaflux test systems.



Get started in vacuum metallurgy this sensible pay-as-you-grow way

You may never need more than the basic 50-to-200 lb. capacity of the CEC vacuum induction furnace shown above. It's ample for medium-scale melting and casting. But if your needs change, as they well may in this rapidly expanding field, you can easily increase capacity to 300 lbs. Just open the flanged nozzle (arrow, left) and add another pumping system. Similarly, with the CEC laboratory and pilot plant model, you can start out with 5 lb. melts, then only change crucibles to accommodate 12, 17, 30, even production-rate 50-lb. melts. Same with the big CEC large-scale production model . . . it's expandable from 300 to 1000 lbs. The capacity is there, if you want it. You pay only for what you need, when you need it.



CEC gives you room to grow

WRITE for informative Bulletins P4-30, 32.

Consolidated Electrodynamics

Rochester Division, Rochester 3, N.Y.

SALES AND SERVICE OFFICES IN PRINCIPAL CITIES

Personals . . .

George H. Bierman has retired as supervisor of the American Can Co., Newark, N. J., and will conduct a personal consulting and service business in physical metallurgy and materials engineering in Bloomfield, N. J. A member of ASM for 38 years, he served on the board of directors of the Cleveland and New Jersey Chapters.

Walter A. Pyhrr has been appointed a sales representative in the Chicago sales district of Selas Corp. of America, Dresher, Pa., in line with the recent expansion of the Chicago sales district. Since 1952 he had been associated with Gas Appliance Service, Inc., Chicago, as sales manager.

Isadore Caplan has been appointed chief engineer of the new Mark Tubing, Inc., Rochester, N. Y., plant. He was formerly at the Rochester Products Div., General Motors Corp., where he was supervisor of tubing process engineering.

Vaughan C. Reid has been elected president of City Pattern Foundry & Machine Co., Inc. Affiliated with the company since 1934, he was made vice-president in 1941.

Gilbert A. Hanke has been named product manager, stainless tubing, for Allegheny Ludlum Steel Corp., Pittsburgh. Hanke joined Allegheny Ludlum in 1942 and for the past three years was general superintendent of the extrusion and cold draw department at the company's Watervliet, N. Y., works.

G. D. Welty, manager of engineering sales for Aluminum Co. of America, Pittsburgh, has retired following 37 years of service with Alcoa. Joining Alcoa in 1921, he has been located in Pittsburgh since 1953, first as manager of aircraft industry sales and since 1956 as manager of engineering sales.

Walter Arrowsmith has been promoted to lead engineer in the metallic materials group of Thiokol Chemical Corp., Brigham City, Utah.

Alexander V. Wesolowski is currently employed as a development engineer for Aerojet-General Corp., Sacramento, Calif.

Introducing Allied's

IRILAC™ #1000

New Clear Protective Coating for All Metals . . . as safe and easy to handle as Water!

New method of protection incorporates corrosion inhibitors in a water-soluble polymer base. Dries to an extremely thin, tough, durable coating—clear in color. Does not chemically affect base metal or any post-treatments. Used as a protective treatment alone or to enhance value of post-treatments.

Allied's new Irilac #1000 is a concentrated solution of a water-soluble polymer with built-in complex corrosion inhibiting materials. It was developed to answer the needs of the metalworking industry for a non-conversion process that will provide corrosion resistance and resistance to fingerprinting and abrasion on base metals and electrochemically or chemically finished surfaces—without changing the appearance of the metallic surface.

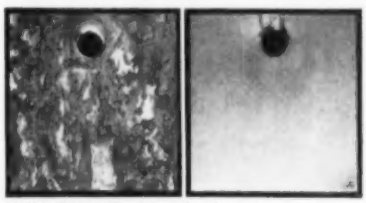
There are no hazards involved—Irilac is non-fuming, non-toxic, and requires no special fire prevention measures.

THE PROCESS

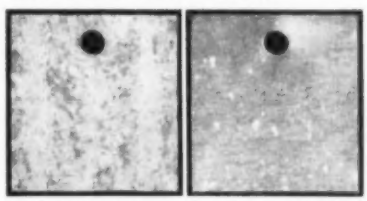
Irilac #1000 is diluted with water to provide a simple one-pass working solution. It is then applied by dip, brush or spray and forms a coating that quickly *bonds* to the metal surface without reacting with the surface.

THE PROPERTIES

The resulting coating is clear, transparent, thin yet durable. It has excellent water-resistant properties, and can be rubbed, handled and subjected to rough treatment. The surface to which Irilac has been applied is not altered—in fact, the transparent coating brings full tone to colored surfaces and clarity to iridescent surfaces. The water-thin physical characteristic of the solution means that the coating provides protection in recessed areas that are difficult, if not impossible, to protect with other methods.



STEEL PANELS: bare (left) and coated with Irilac (right) after 8-hour salt spray.



ALUMINUM PANELS: bare (left) and coated with Irilac (right) after 168-hour salt spray.

WHERE IRILAC CAN BE USED

Irilac #1000 can be applied to *any* metal—wet or dry—treated or untreated. All metals can be processed in *one* operation in the same solution. It can be applied in conjunction with any process—over Iridite, anodized, phosphated surfaces, black oxide, etc. Surfaces treated with Irilac provide a good base for paint.

APPLICATION ADVANTAGES

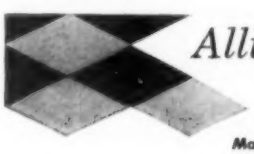
No other process or material available for the protection of metals offers all the application advantages found in new Irilac #1000:

1. It can be applied to *any* clean metal simply by dip, brush or spray. No special equipment is required.
2. Saves time—just apply and dry—no reaction time required.
3. No hazards involved—no exhaust or special fire protection equipment is required. Irilac is non-fuming and non-toxic.
4. Saves space. Presents no disposal problem. Low in first and final costs.

Because of its versatility and complete safety, Irilac has unlimited uses. For example, it will protect aluminum furniture, brass hardware and fixtures, steel parts of all types, zinc castings, etc. In fact, any base metal or plated surface, or those treated with electrolytic or chemical post-treatments, can be improved or enhanced with Irilac.

IRILAC #1000 MAY BE THE ANSWER TO YOUR PROTECTION PROBLEM

Our development staff will be glad to work with you to determine the significant benefits Irilac can offer you. Simply send us some parts and let us show you what Irilac can do. No obligation, of course.



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AO Spencer Picture-in-a-minute Photomicrography

When you use the AO Spencer Photomicrographic Camera equipped with the Polaroid® Land Camera back, permanent photographs are ready for your files in just 60 seconds. A coupled visual and photographic system lets you shoot what you see . . quickly and effortlessly. And with the Polaroid back possible errors in exposure, illumination or focus can be corrected immediately.

In addition to the Polaroid Land camera back, you have a choice of 4 other *readily interchangeable* camera backs; 4" x 5" fixed back; 4" x 5" Graflok back; 35mm back and Bantam back (roll film). You choose the camera back and film best suited to your specific requirements.

Here, the No 682G Camera is shown being used with the new AO Metalstar Metallurgical Microscope . . . an ideal combination. The stage is focusable . . . your eye level remains constant . . . also, because the vertical illuminator remains at a fixed height throughout all focusing adjustments, you can conveniently use an external light source in place of the illuminating unit.

The sturdy vertical pillar, the easily adjustable camera support, the camera back and the Metalstar all combine to provide a compact unit. Perfect alignment and rigidity is assured . . . successful photomicrography becomes a "snap".

Try it and see for yourself. Your AO Representative will be happy to arrange a demonstration for you.

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☐ Please send me Brochure SB682 describing the entire line of AO Spencer Photomicrographic Cameras.
☐ Please send me Brochure SB2200 describing the new Metalstar.
Name_____
Address_____
City_____ Zone_____ State_____

Personals . . .

Vernon H. Patterson has been appointed metallurgical engineer by Vanadium Corp. of America. Mr. Patterson will be affiliated with the engineering sales division and will make his headquarters in the company's Chicago office.

Albert P. Gagnebin was recently elected a vice-president of the International Nickel Co. Inc., New York. Affiliated with Inco since 1930, he was named manager of the nickel sales department in 1956 and a year later elected an assistant vice-president. At the same time, **Joseph M. Weldon** has been elected an assistant vice-president. He has been assistant to the vice-president of Inco since 1953 and has been with the company for more than 30 years.

Thor N. Rhodin has joined the staff of Cornell University as associate professor of engineering physics and metallurgical engineering. In addition to his teaching duties, he will direct research on surface physics under the support of the Office of Naval Research.

James H. Dodge has been named sales manager of specialty steels for Latrobe Steel Co., Latrobe, Pa. A member of the sales staff for 25 years, he has been regional sales manager of the Detroit branch for the past 14 years.

Nelson J. Donahue was recently appointed chief of the reactor materials branch, technical and production division, Savannah River operations office of the U. S. Atomic Energy Commission, succeeding **Paul J. Hagelston**. Mr. Hagelston is now deputy director of the division. Mr. Donahue has been a materials engineer in the reactor materials branch since 1952.

Richard Doughton, Jr., a development engineer for Jones & Laughlin Steel Corp., has been appointed supervisor of product development for the company's stainless and strip division in Detroit.

George P. Michalos has been promoted to superintendent of inspection for the steel and tube division of the Timken Roller Bearing Co., Canton, Ohio. He was formerly general foreman of finish tube inspection at the Gambrinus, Ohio, Timken plant.

ELECTROMANGANESE®

just naturally takes to alloying

High purity (99.9%) and inherent compatibility make Electromanganese an ideal alloying element. The absence of silicon, carbon, and other impurities gives ferrous and nonferrous metallurgists an alloying element that produces uniform results . . . provides a whole string of selected and unique properties. Electromanganese alloy combinations run the metal gamut from A to Z. Here's a sampling of the properties Electromanganese adds to—

	**Aluminum**	desirable hardness with no harmful effect on corrosion-resisting properties; improved strength at elevated temperatures
	**Copper**	high strength and high resistance to chemical corrosion; also provides unusually high damping characteristics and electrical properties
	**Iron**	high strength, toughness, good drawing and machining properties; also counteracts the harmful effects of sulfur
	**Magnesium**	improved resistance to corrosion by salt water, increased yield strength of the wrought alloys; also confers weldability
	**Nickel**	improved malleability, high heat-dissipating capacity and high resistance to oxidation and corrosion at high operating temperatures
	**Titanium**	high strength to weight ratio combined with good formability
	**Zinc**	increased strength, workability, and corrosion-resisting properties

Electromanganese—Foote's electrolytic manganese—is also used as a substitute for rarer, more expensive metals . . . as a melt deoxidizer and scavenger. Electromanganese may well be the key to your search for newer, better metals.

To find out more about the potential of Electromanganese you ought to have our Bulletin 201. Write letterhead request to Technical Literature Dept., Foote Mineral Co., 424 Eighteen West Chelten Building , Philadelphia 44, Pa.



FOOTE MINERAL COMPANY

Electrolytic Manganese Metal • Nitrelmang • Hydrogen-Removed Electromanganese • Nickel • Rimex Manganese Sulphide • Welding Grade Ferro Alloys • Commercial Minerals and Ores • Lithium Metal, Chemicals, Minerals • Zirconium, Titanium, Hafnium (Iodide Process)



Metals Engineering Digest

. . . Interpretative Reports of World-Wide Developments

Better Aircraft Engines

Digest of "The Aircraft Engine — A Proving Ground for New Materials", by W. Paul Eddy. 16th Annual William Park Woodside Lecture presented before the Detroit Chapter ASM on Oct. 13, 1958.

SEVERAL INCENTIVES inspire the aircraft engineer to develop a new material or process. He may be able to make the engine or component work, make the engine work better, reduce weight, lower costs, or use more plentiful materials.

For example, various measures have improved roller bearings. Lightly loaded rollers are likely to skid in the races; this is now prevented by preloading through grinding outer races with a slightly elliptical contour. Spalling is known to be aggravated by inclusions; now a cleaner 52100 steel (provided by vacuum melting) has lowered fabrication losses considerably. The problem of heat – temperatures may go up to 1000° F. – has been minimized by use of steels with special analyses. Some are shown below:

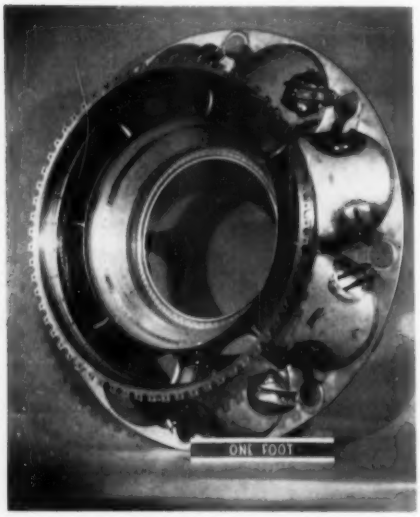
	A	B	C	D
C	0.73	0.88	0.81	0.13
Mo	–	8.0	4.25	5.0
W	18.0	–	–	–
Cr	4.0	4.0	4.0	1.5
V	1.0	2.0	1.0	–
Ni	–	–	–	2.8

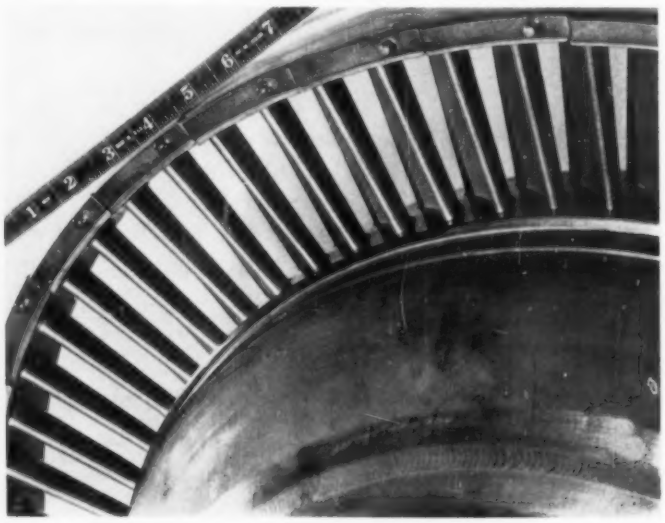
Another big problem has been stress-corrosion in compressor disks. After much investigation, we found a low-alloy steel (0.45% C, 0.55% Mn, 0.95% Cr, 0.55% Mo, 0.30% V) that was more resistant than any hardenable stainless steel. Since creep strength was also excellent, we decided to use it. Its one drawback was lack of corrosion resistance – we needed a coating.

After much work, a diffused nickel-cadmium electroplate was devised. Finished parts are plated with 0.0003 in. nickel, then with 0.00015 in. cadmium. Heating at 630° F. for 30 min. follows. Such parts are more rust resistant, stress-corrosion resistant and corrosion-fatigue resistant, have higher yield strength and creep strength, and are cheaper than parts of any hardenable stainless steel we have seen. Furthermore, this plate does not embrittle the base steel when heated above the melting point of cadmium.

A number of our material difficulties have been solved by the constant improvement in superalloys. The special vacuum-melted grades (Waspaloy, M-252, Udimet 500, Incoloy 901 and others) have been very helpful. However, the end

Fig. 1 — These Parts Face the Highest Temperatures in a Jet Engine. At the left is a transmission duct made from a wrought alloy; the other is a cast turbine nozzle guide vane assembly

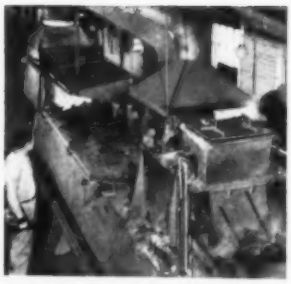






To keep immersion heating jobs moving . . .

Come to Kemp



Thirty-two ton Kemp Immersion Melting Pot keeps production on a 24 hour basis at Stanley Works, New Britain, Conn. Steel strapping is annealed on a continuous basis with important savings in time and fuel costs.

Where speed plus a high degree of control counts, depend on Kemp Immersion Heating Units. Kemp units give you sensitive and accurate control of heating needs for annealing, tempering, melting soft metals, and in many other applications.

Unique Kemp design puts the heat where it belongs . . . next to the material being heated. It goes to work immediately, without wasting time heating heavy pots, practically eliminates overrun and lag. The Kemp Industrial Carburetor, the basis for Kemp engineering design, premixes fuel gas and air to optimum ignition conditions. You get a cleaner operation with appreciable savings on fuel costs.

This kind of efficiency pays off with a better finished product at lower cost. You can forget about delays, cracked pots, exposed flame, and wasted down time. With Kemp Immersion Heating Unit at work for you, you can expect the finest performance of its kind—the result of a quarter century's pioneering experience.



Capacities from 1 to 75 tons—melting rates up to 26 tons per hour. For more information and practical suggestions, call in your Kemp Representative or write us direct for Bulletin IE-11. *The C. M. Kemp Mfg. Co.*, 405 E. Oliver St., Baltimore 2, Md.



Convection Dryers



Inert Gas Generators

KEMP OF BALTIMORE



Industrial Carburetors



Oriad Dryers



QUENCHED from 1600°F to 300°F, this 10½-foot gear owes its uniform hardness to violent agitation of quench water by five propeller-type side entering LIGHTNIN Mixers, installed near bottom of 12-foot-deep tank, below floor level. See diagram below.

No soft spots *in this 7½-ton gear*

How do you get uniform hardness in a cast steel gear weighing 7½ tons?

The Falk Corporation (Milwaukee) does it with this king-size water quench tank, equipped with five 25-horsepower propeller-type LIGHTNIN Mixers.

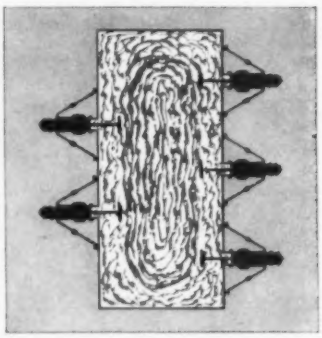
The gear is quenched at Wisconsin Steel Treating & Blasting Co. for The Falk Corporation, who engineered the process.

To speed heat extraction, the LIGHTNIN Mixers churn the water violently during quenching. The resulting turbulence constantly *wipes* and *wets* every square inch of the huge gear surface.

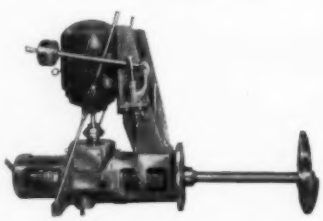
Temperature of the gear drops from 1600°F to 300°F—producing the desired hardness over the entire gear, which is 10½ feet in diameter.

"We are fully satisfied with LIGHTNIN Mixers for this important quenching operation," says Edward J. Wellauer, Falk's Assistant Chief Engineer. "The mixers were installed late in 1953 and have given us excellent results ever since."

Don't let size keep *you* from getting better physical properties, greater toughness in quenched parts. You can improve hardness uniformity, reduce or eliminate warpage and cracking, retreats and rejects—by quenching parts as small as a lock washer, as big as a 105mm gun barrel, with LIGHTNIN Mixers. Write us today for facts on LIGHTNINs that will give you the results you want.



UNIFORM TURBULENCE in bath wipes vapor film rapidly from entire surface of gear, for maximum liquid contact and best possible heat transfer conditions.



SIDE ENTERING unit is one of many LIGHTNIN types you can get, in sizes from ⅛ to 500 HP. You can use LIGHTNIN Mixers for standard quenching, martempering, austempering; for batch or continuous work; in new or existing quench tanks of any size and shape.

Lightnin® *Mixers*™

MIXING EQUIPMENT Co., Inc.

171-B Mt. Read Blvd., Rochester 3, N. Y.

In Canada: Greey Mixing Equipment, Ld., 100 Miranda Ave., Toronto 19, Ont.

Aircraft Engines . . .

of the road seems near for the nickel and cobalt-based alloys. We need a new series of more refractory alloys, particularly for parts such as those shown in the photograph.

Aircraft engineers go to considerable lengths for the proper combination of properties. Consider the following brazing alloys, for example: A with 82% Au and 18% Ni, and B with 72% Au, 22% Ni and 6% Cr.

Alloy B (as compared with A) is a little lower in cost and has slightly better oxidation resistance at elevated temperatures, but requires a little higher brazing temperature and has slightly inferior wetability. These alloys can be used for furnace brazing in hydrogen, induction brazing with a protective atmosphere of 98-2 argon-hydrogen, or vacuum brazing. Compared with copper they are (*a*) stronger in shear at all temperatures, (*b*) have 30% higher fatigue endurance limit and greater oxidation resistance, (*c*) form smoother fillets and alloy less deeply with base metals, and (*d*) can be brazed at temperatures 150 to 250° F. lower.

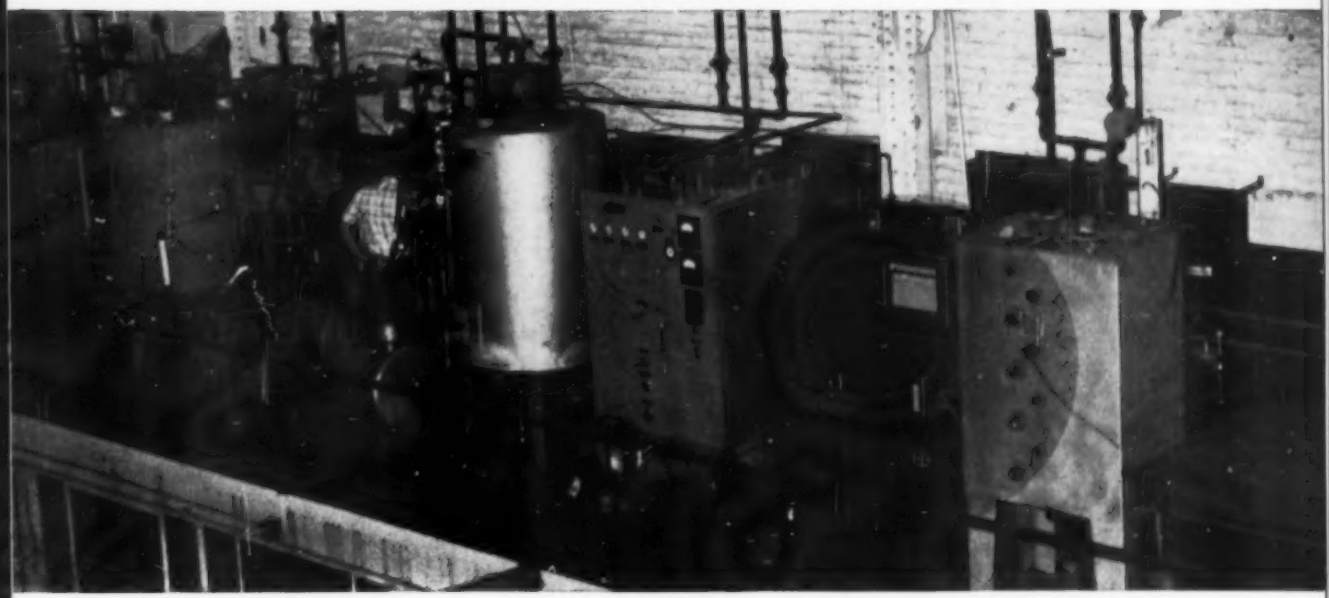
Since gold costs $35 an ounce, it is evident that these property advantages are important to us. We use these alloys to furnace-braze fuel manifolds (stainless steel assemblies with many joints).

Another material we find useful is dispersion-hardened aluminum. This is usually made from aluminum powder, mill-ground (with a little stearic acid) to very thin flakes. Flake thickness determines oxide content; high oxide is obtained by grinding thinner. Powders are then compacted under heat and pressure.

Though strength and ductility at room temperature are lower than those of conventional aluminum alloys and notch sensitivity is high, strength and hardness above about 500° F. are much higher. We use dispersion-hardened aluminum only in one application. A jet engine equipped with afterburner has an exhaust nozzle which must open practically instantaneously whenever the after burner is fired, and must close when the afterburner is turned off. Cylinders operated by compressed air do the work. Strenuous efforts were made to reduce

M-S-A® LIRA Analyzers help control dew point of furnace atmospheres

You can prevent damaging oxidation and change in carbon content of metal surfaces by measuring water vapor content with M-S-A infra-red analyzers



Typical installation shows M-S-A LIRA Analyzer calibrated for suitable dew point ranges to determine carbon potential of the furnace atmosphere.

Heating metals like steel, copper, brass, etc., generally makes them chemically active with the atmosphere in the furnace.

Such atmospheric furnace action may damage the surface of the metal. It may cause scaling by oxidation. Or change in surface carbon by carburization or decarburization.

To combat this quality control hazard, many metallurgists are holding the carbon range to much closer tolerances with dew point control by infra-red analysis. And they're using M-S-A LIRA Analyzers to do the job. Safely. Reliably. Accurately.

Since water vapor is such an ideal absorber of infra-red radiation, M-S-A LIRA Analyzers are extremely well-adapted for controlling the dew point of a furnace atmosphere.

There are a number of M-S-A LIRAs installed in annealing operations of strip steel and special carbon steels, and also in pure hydrogen atmospheres where hydrogen brazing is taking place.

Principle of operation for the M-S-A LIRA is simple. The gas sample passes through a sample cell through which an infra-red beam is directed. This direct beam measurement eliminates the problems usually encountered in such analysis: getting water vapor to react with some salt, or cooling it to cause a frost on a mirror, etc.

An MSA Instrument Specialist will be pleased to discuss your specific problems with you. Write for information regarding your particular problems of atmospheric analysis and control.

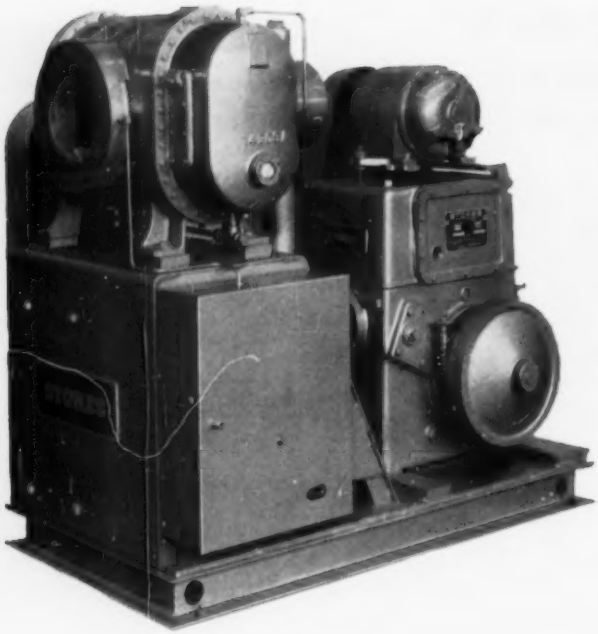


The entire assembly of the M-S-A LIRA Analyzer is mounted on a self-supporting panel. All adjustments are easily made from the front of the panel.

INSTRUMENT DIVISION

Mine Safety Appliances Company

Pittsburgh 8, Pennsylvania



STOKES MECHANICAL BOOSTER PUMPS

Packaged high-speed pumping systems that feature automatic push-button operation

Stokes Mechanical Booster Pumps are streamlined, compact integrated systems that offer the user greater pumping speed per dollar. The unit consists of a coaxial blower first stage, backed by the latest gas-ballasted Microvac rotary vacuum pump. Four models are available . . . Model 1710, with a 1050-cfm rating—Model 1711, rated at 1160 cfm—the 1712, rated at 2900 cfm—and the 1713, rated at 5100 cfm.

Operation of this Stokes system is entirely automatic. When the pressure has been roughed down to 15 mm Hg, a pressure switch actuates the blower unit. There are no complicated switching or valving procedures necessary. All models feature an ultimate blank-off of 0.5 microns and tremendous throughput.

Call your nearest Stokes office, or contact Stokes' Engineering Advisory Service for complete specifications on all models—or application assistance for your own specific process.

Vacuum Equipment Division
F. J. STOKES CORPORATION
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STOKES

Aircraft Engines . . .

weight of these mechanisms, but because of the high temperatures encountered (up to 650° F.) and good frictional properties needed, we were unsuccessful until dispersion-hardened aluminum came along.

Titanium

Much money has been spent on development and aspirin since we began work with titanium at Pratt & Whitney Aircraft. From the technical standpoint, it has been a series of headaches. The first one (excessive grain growth during forging) was solved by forging not higher than 1750° F. with considerable reduction in the final operation.

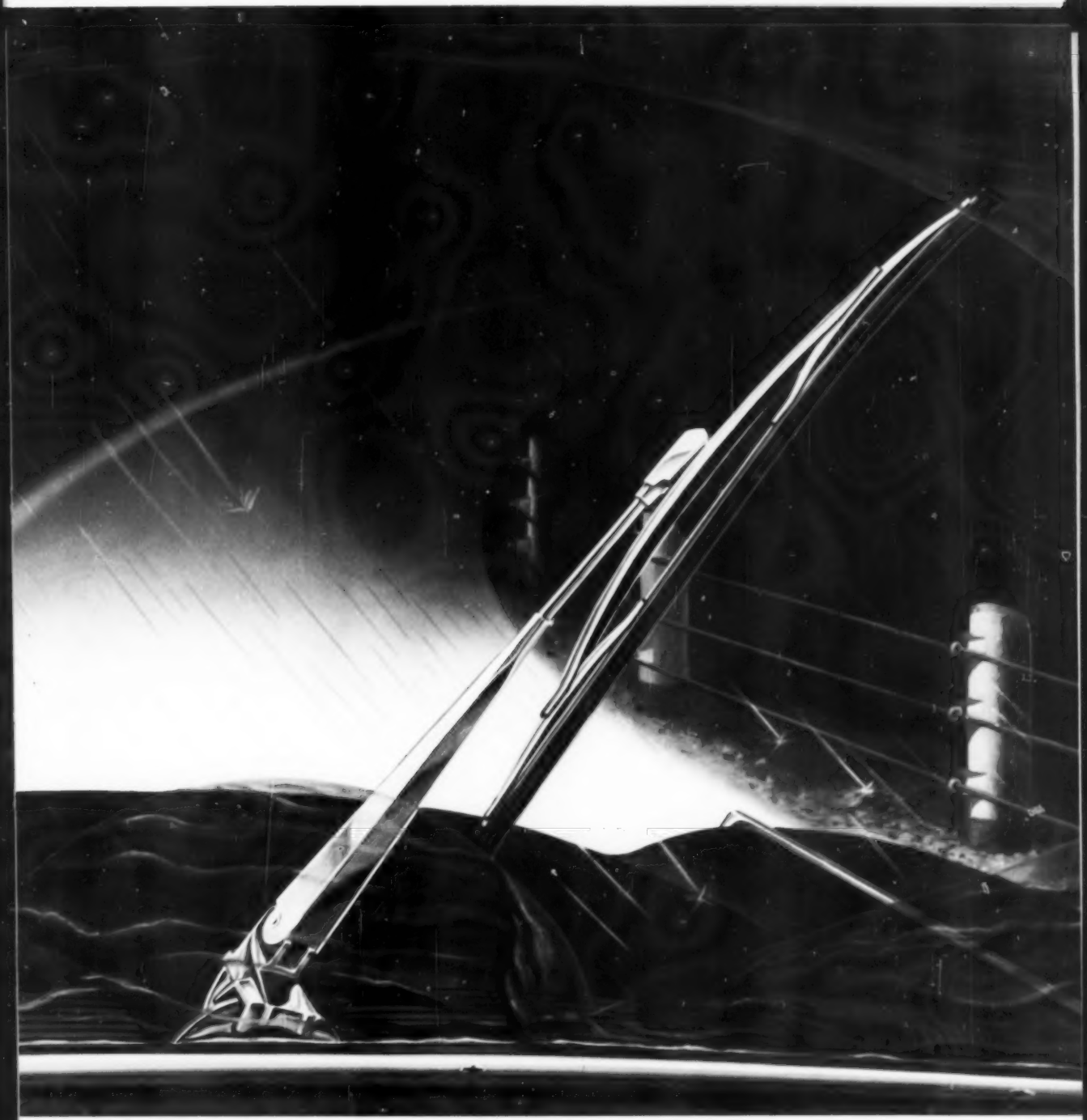
Fabrication techniques also gave much difficulty. Machining was the least trouble; we found that titanium alloys machine more easily than austenitic steels though not quite as easily as the ferritic stainless steels. Sheet metal forming was more difficult. Various hot forming techniques, however, made possible the fabrication of shapes as intricate as those previously formed from stainless steels. Welding can only be done in an inert atmosphere. Grinding with reasonable care is not harmful to titanium — in fact, under certain conditions, compressive stresses are obtained at ground surfaces.

Carbon, hydrogen, oxygen and nitrogen in large amounts all have an embrittling effect. Today, all titanium is vacuum-melted to eliminate the gasses. Another bugaboo, salt-stress-corrosion, is not too worrisome because titanium is not used in vulnerable zones. Plating is difficult, and therefore is not done.

From experience we have standardized on three titanium alloys: 6A1-4V alloy (machined parts for use up to 750° F.), 5A1-2.5Sn alloy (sheet metal or welded parts for use up to 650° F.), and commercially pure titanium (for sheet metal or welded parts for use under moderate stresses up to 350° F.).

Weight Reduction

If certain steel parts are replaced with titanium parts, considerable weight reductions result. The J-57 engine, for example, can be lightened by 443 lb. Of course, it has cost about $100 per lb. of weight saved in this manner, but this is



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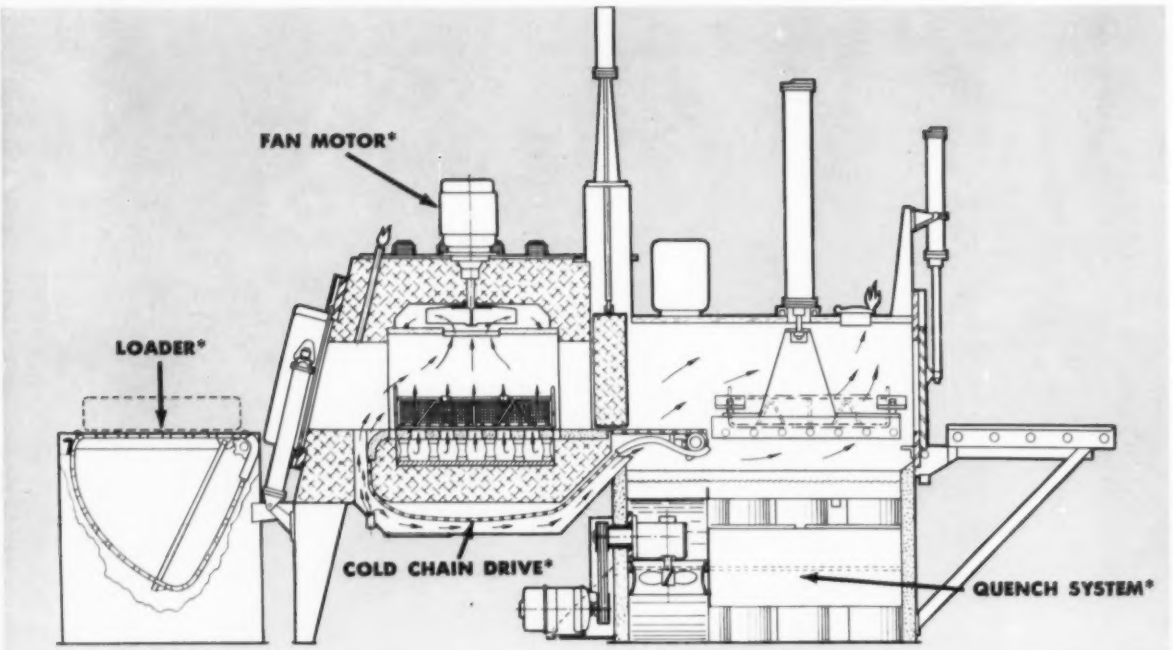
Superior Steel

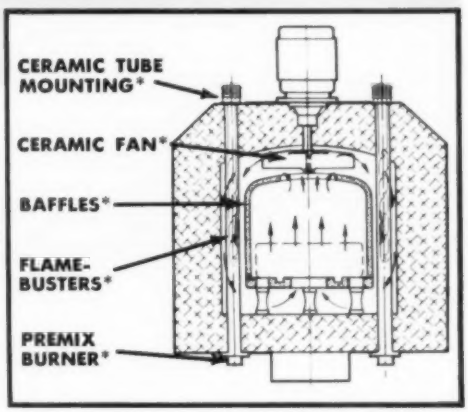
DIVISION OF

COPPERWELD STEEL COMPANY

CARNEGIE, PENNSYLVANIA

Export: Copperweld Steel International Company, New York





*Existing or Pending Patents

Ipsen announces new model "C" furnaces

for carburizing up to 2000°F

For years, the top operating temperature of conventional carburizing furnaces has been in the area of 1750°F, but the new Ipsen Model "C" Carburizing Furnace coasts at that temperature. The model "C" is engineered to meet modern requirements for high temperature carburizing.

EXCLUSIVE IPSEN FEATURES!

Here are some of the reasons why Ipsen Model "C" furnaces permit day-in and day-out operation at 2000°F:

1. Guaranteed super-alloyed ceramic heating tubes!
2. Unique tube mounting, sealed in compression!
3. Ceramic "Flame-Busters" increase heating efficiency 40%!
4. High hot-strength hearth and baffles for 100% forced convection heating!
5. Revolutionary, high-speed, forced circulation fan of alloyed ceramic construction!
6. Water-shielded fan shaft and motor!
7. New, fully enclosed, 100% premix ceramic burners!
8. "Cold chain" hot-work transfer mechanism with automatically welded precision chain!
9. Bevel gear driven quench oil propeller. . 5,000 gallons per minute!
10. Space saving automatic loaders and in-line transfer mechanisms!

Optional "*Dewtronik*" is the only automatic dew point control for either carburizing or ammoniated carbo-nitriding atmospheres.

Call your nearest Ipsen office for the complete facts on the NEW Ipsen Model "C" 2000°F Carburizing Furnace.

AUTOMATIC Ipsen HEAT TREATING UNITS

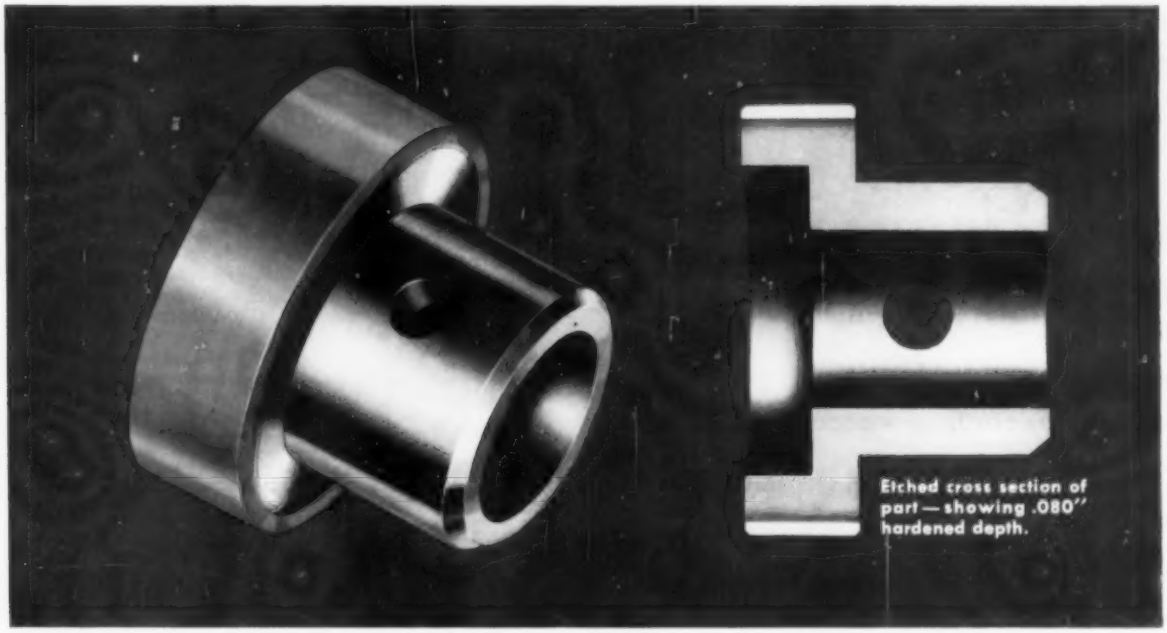
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TOCCO* *Induction Heating*

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Degrease	$0.0020	eliminated	
Carburize	0.0200	eliminated	
1st quench	0.0150	TOCCO, heat and quench	$0.0060
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Draw	0.0050	eliminated (self-draw)	
Shotblast	0.0035	eliminated	
Internal Grind	0.0243	eliminated	
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	$0.1014		$0.0060

"... Savings of 9½ cents per piece—$4770.00 on each 50,000 piece batch, *plus* an hourly production increase from 120 to 300 pieces per hour, plus improved quality of the product by virtue of the deeper case and stronger core."

Have you investigated TOCCO's cost-savings possibilities for your hardening, brazing, melting or forging operations? Why not write us today or send blueprints of your parts—no obligation, of course.



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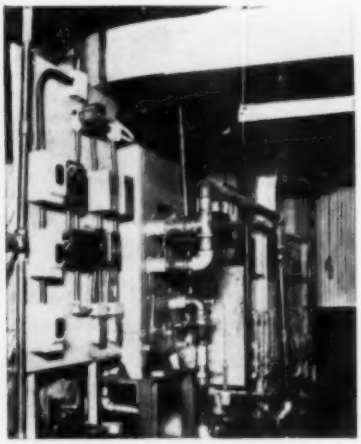
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Aircraft Engines . . .

expected to drop to around $40 per lb. in the near future.

How much is it worth to save a pound of weight? Weight saved in engines can mean an airplane that is lighter by several times the reduction in engine weight. Less powerful engines and less fuel are needed for the same performance. Or the engine and supporting structure weights that are saved may be used to get higher speed, greater range, or more payload.

Studies of various four-engine airplanes produce, as might be expected, various results. For a certain short-range domestic transport the worth was $20 per lb. of weight saved. The highest was for an unusual transoceanic airplane – $240 per lb. In most instances the values are between $40 and $93 per lb.

With savings like these, it is easy to understand why aircraft engines must be carefully designed so that every ounce is doing its part – there must be a minimum of dead weight and low-stressed metal. Continued development work results in increased power or thrust without proportionate increase in weight. In turbine engines, conventional aluminum and magnesium alloys can be used only in cold portions. This leads to consideration of titanium at moderately elevated temperatures for reducing weight directly by substitution, and to research on improved superalloys that will bring about increased efficiency without added weight.

C.R.W.

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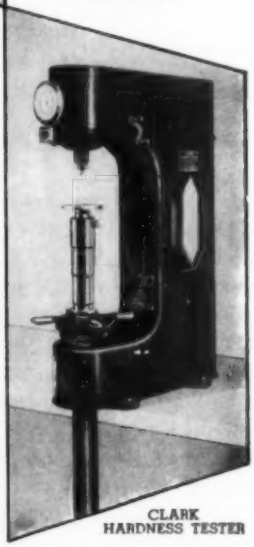
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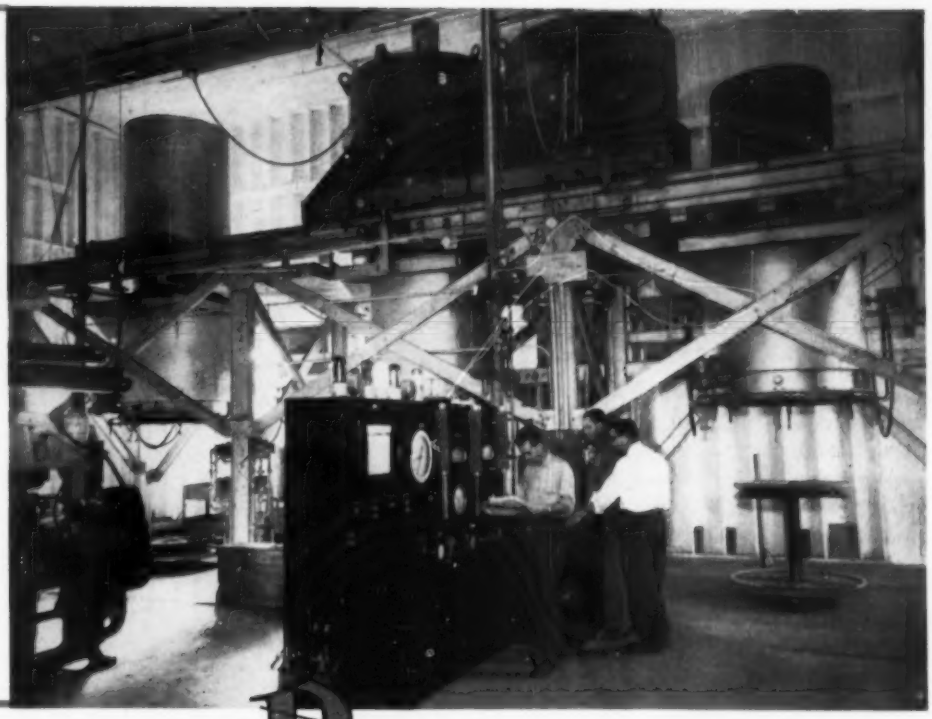
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Designed and built by Pacific Scientific for Solar Aircraft Co., this new triple elevator, two furnace installation is equipped with program controls to give fully automatic operation of temperature, time and atmosphere.

Push one button, and the installation will perform almost any number or combination of processing conditions required for any specific high-temperature brazing sequence. Once set and started, the installation is on its own. The operator need only make adjustments as signalled by the system's lights and buzzers.

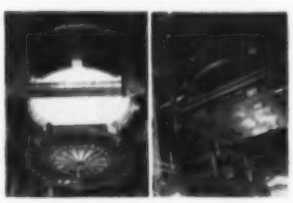
With exact programming schedules under automatic control, consistent high quality of all parts is assured. And these parts are processed on a fast production basis. The entire operation of heating and cooling as well as the purge gas and process gas—is continually controlled and recorded. Unique atmosphere safety-control panel works with temperature control instruments to produce identical cycles—unequalled in performance.

Believed to be the only one of its kind in the United States, this installation is a good example of Pacific's creative engineering that has resulted in a unique furnace to speed production, reduce costs, improve product quality, and eliminate human error. This is the type of creative engineering one can expect from Pacific Scientific.

Whether your needs call for a standard design furnace or a special furnace such as Solar's furnace with a "brain"—Pacific can be of service to you. For specific information, call or write Pacific Scientific Co. today!

THIS SOLAR FURNACE SUPPLEMENTS TWO OTHER PACIFIC INSTALLATIONS OF ADVANCED DESIGN

... good evidence of a satisfied customer! Shown to the right are the two other Pacific Furnaces designed and built for Solar to provide high speed production brazing of honeycomb parts. Each has inside dimensions of 8 ft. in diameter by 10 ft. high with a capacity for two tons. Each is capable of brazing honeycomb parts that will withstand 1600°F. continuously and 2000°F. intermittently. Each is typical of the creative engineering you will find at Pacific.



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NOTE: Order 8 oz. for each charge in a standard absorption pipette; 3 oz. for Industro® gas analyzers.

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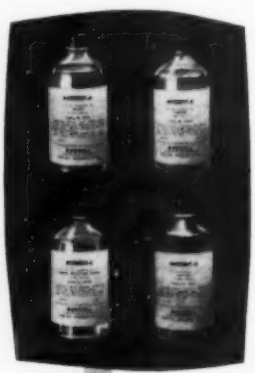
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Scientific Apparatus and Laboratory Supplies
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Stainless Steel in Automobiles

Digest of papers presented at the A.I.M.E. Electric Furnace Conference, Detroit, December 1958.

ALTHOUGH the cost of stainless steel tends to limit its use, automakers have used more and more of it since it was first employed for hubcaps in 1928. Nothing like today's full-circle wheel covers, according to C. O. Durbin (Chrysler Corp.), these hubcaps were only 3 in. in diameter; the total weight per car was less than 8 oz. Today between 19 and 45 lb. is used for trim. The types employed, 301 and 430, have not changed since the early days, though 201 is sometimes substituted for 301. Type 301 is used for wheel covers and windshield wiper arms, and Type 430 is used for moldings, hubcaps, headlamp doors and retaining rings, radiator grilles and similar parts.

Color is important. Since stylists prefer the bluish tint of chromium, Types 301 and 201 are often given a chromium flash to cover their natural yellowish tinge. The luster of Type 430 is generally satisfactory by itself, though it is sometimes flashed with chromium for better wear or to match an adjacent plated part such as a bumper. Stainless steel, despite its name, is subject to pitting, and care must be taken both in manufacture and fabrication.

Experience has shown that stainless steel parts, particularly decorative surfaces, must be kept clean during manufacture. Furthermore, excessive inclusions appear to promote rusting. Copper, steel or iron contaminations on surfaces are particularly harmful. Tools used for processing carbon steels, steel files, and iron-containing buffing compounds should not be used. Copper alloy dies also contaminate surfaces. Surface contamination combined with sodium chloride used for deicing will cause rusting. The 5% neutral salt spray test is considered a satisfactory test for automotive stainless steel trim.

How Much Is Used

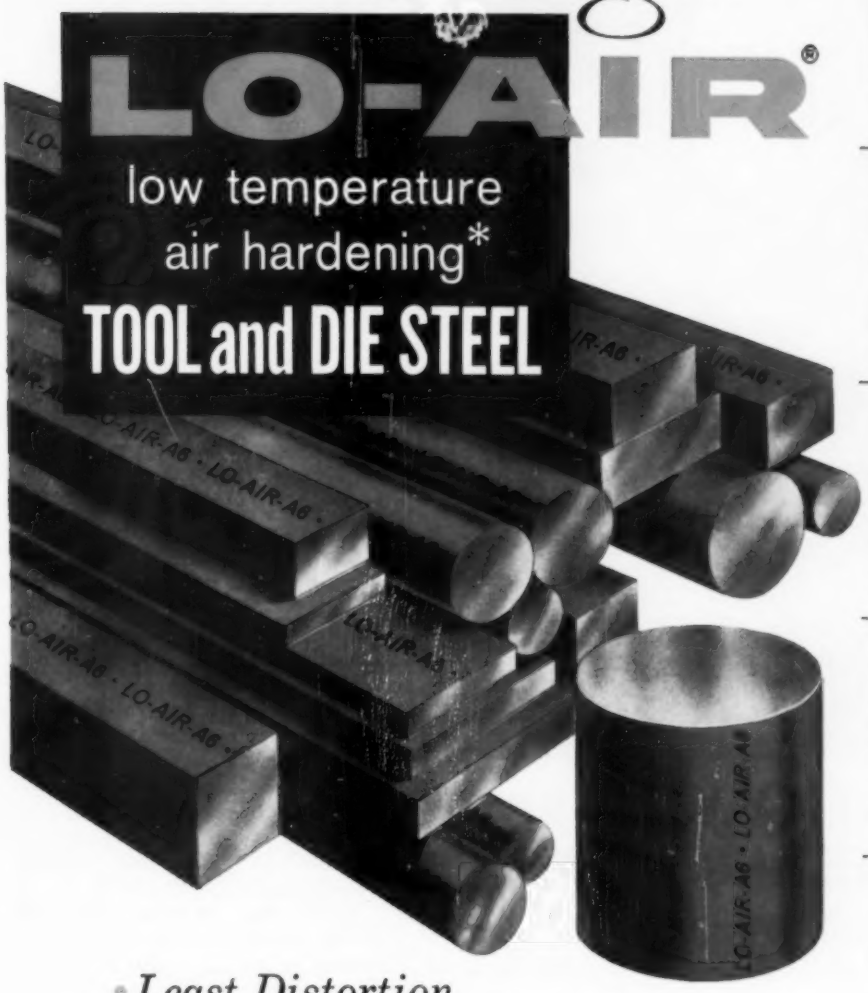
Current usage of stainless steel in cars has not varied in the last five years. The table below shows that 29 lb. was used for one typical model

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**U. S. PAT. NO. 2,355,244*

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Courtesy Sundstrand Aviation, Rockford, Illinois.

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Stainless Steel . . .

(a Plymouth) in 1954; the same amount is used in the 1959 models.

Year	Weight
1959	29 lb.
1958	18
1957	20
1956	25
1955	25
1954	29
1953	19

The 1957-58 drop was caused by the increased use of anodized aluminum, a material which has been receiving more attention by automakers recently.

Alternate Materials

Stainless steel receives competition from other materials; this point, brought out by Mr. Durbin, was confirmed by D. N. Frey, Ford Motor Co. Automobile trim can also be made of cold rolled steel, zinc die castings, and brass (all chromium plated) as well as anodized aluminum. The material selected depends on the shape of the part, appearance, strength requirements, and over-all cost. In most instances, costs of the various materials are competitive (thought it is apparent that a stainless steel bumper would cost considerably more than chromium-plated, cold rolled steel bumpers now used).

Many times, the stylist has the last word on the material to be used. Since he generally prefers the appearance of chromium, stainless steel and brass will often be plated with chromium, though this may not be necessary from a corrosion standpoint. If sharp corners are desired (in a nameplate or an insignia, for example), the part will be die cast. These parts have to be plated for corrosion resistance as well as appearance. Grilles and headlight rings are usually plated to match the chromium plate on the bumper.

Automakers use tests involving various salts found in the atmosphere and on the roads to determine corrosion resistance of trim materials, and find that chromium-plated, cold rolled steel parts have the lowest resistance while stainless parts stand up the best. (This will be no surprise to drivers in Northern cities who, in a sense, conduct their own salt spray tests every winter. All of

Specification

3-G-170

Trade names you can trust!

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Chromel-Alumel

THERMOCOUPLE ALLOYS

Specification

3-G-178



Available guaranteed to special close tolerances for precision laboratory and research work

Hoskins standard grade Chromel-Alumel thermocouple alloys for industrial heat treating applications are unconditionally guaranteed to register true temperature – e.m.f. values within ±4° F. from 32° to 530° F., and within ±¾% at temperatures from 531° up to 2300° F. For precision laboratory and research work, however, Chromel-Alumel is available under specification #3-G-170 in suitable selected wire sizes guaranteed to the special close tolerances shown in the table at right. Or, under specification #3-G-178, they are also offered in sizes from 2 through 40 gauge guaranteed to one-half the standard grade tolerance in the range from 1050° F. to maximum recommended operating temperatures.

CHROMEL-ALUMEL – SPECIFICATION #3-G-170

Wire Size	Temp. Range	Tolerance
18, 20, 22 gauge	1000°–2000° F.	±5° F.
24 and 28 gauge	1000°–1600° F.	±5° F.
30 thru 40 gauge	1000°–1400° F.	±5° F.

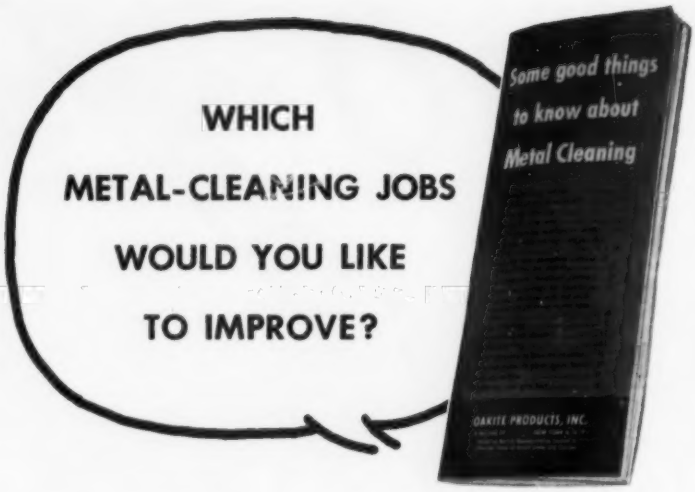
Ask for them by name! Your instrument manufacturer or pyrometer service company can supply your needs for bare or insulated wire and assembled couples – plus Chromel-Alumel *extension lead wire* to eliminate "cold-end" errors. Wires are available, too, direct from factory stocks – so ask for them by name. "Chromel-Alumel" thermocouple wire – *trade names you can trust!*

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¶ Are you cleaning metal the fastest way? *See page 12.*

¶ Do you need room-temperature cleaning combined in one operation with temporary rustproofing? *See pages 12 and 14.*

¶ Do you know the advantages of alkaline pickling? *See page 21.*

¶ Have you compared the values of iron phosphate coating and zinc phosphate coating in preparation for painting? *See pages 22 and 25.*

¶ Can you use a cleaner that removes rust and oil at the same time; often eliminating all need for pickling? *See page 30.*

¶ Do you have trouble stripping epoxy resins, pigment residues, phosphate coatings and under-paint rust? *See page 31.*

¶ How do you clean parts that are too large to be soaked in tanks or sprayed in machines? *See page 31.*

¶ Are you getting full profit out of your finishing barrels? *See page 32.*

¶ What do you do when oversprayed paint neither floats nor sinks in your paint spray booth wash water? *See page 35.*

¶ Do you need better protection against rusting in process or in storage? *See page 37.*

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Stainless Steel . . .

us can testify as to the accuracy of the automaker's research.) Final road tests help determine gages needed to withstand gravel pitting in parts such as hubcaps.

Exhaust Valves

Materials closely akin to A.I.S.I. stainless steels are also used in engine exhaust valves.

In a paper by C. W. Vigor of General Motors Corp., three basic types of valve steels were discussed. These are given in Table I. In exhaust valves, hot strength is an important property; the austenitic types are best from this standpoint, ferritic types the poorest. Engine requirements have increased to such an extent in the last few years that ferritic types are no longer widely used and only limited use is made of the sigma-hardening alloy. A high of 1300° F. is reached on faces of today's valves. If you are wondering how automakers know this, please be assured that the temperature is not measured by a courageous researcher holding a thermometer on top of a rapidly oscillating valve.

Actually, the temperature is determined indirectly. A hardened (but not tempered) valve is installed in an engine which is given a test run for a short period. Naturally, the engine heat tempers the valve. Subsequent hardness measurements determine the degree of tempering, and this, in turn, determines the temperature reached. Although austenitic steels cannot be tested in this manner, data obtained with hardenable alloys can be corrected to approximate the temperatures of austenitic valves. As engine performance increases, better exhaust valve steels will be needed. Laboratories are working on them now.

It might be well to consider that, though the amount of stainless steel used in one car is not large, the number of cars produced in a year is huge. In 1956 and 1957 the automotive industry accounted for about 100,000 tons of stainless; a market of this magnitude interests steelmakers very much.

This meeting, incidentally, used to be known as the "Electric Furnace Steel Conference". With the addition of ferro-alloys to its program last December, the word "Steel" was

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1



2



3

1 *A new gas fired Homocarb said to be the world's largest.*

2 *A Vacuum Heat Treating Furnace for special materials.*

3 *Large capacity vertical furnace for heat treating large parts.*

The three furnaces shown on this page are units of the facilities of commercial heat treating plants in three different sections of the country.

Today, with the ever growing demand for *better* heat treating, economical volume equipment of this sort is becoming essential and the commercial heat treater has been alert to industry's requirements.

Quality work and versatility are the keynotes of this industry's objectives when treating the thousands of vital, intricate, and costly components of important products.

Whatever your heat treating problem, and whether it involves pounds or tons, always consult your commercial plant first.

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Pittsburgh 1, Pennsylvania
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Hartford 12, Connecticut
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Rock Island, Illinois
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dropped. In spite of this, most of the sessions at Detroit were concerned with steel, though production of ferro-alloys, calcium carbide, and titanium and zirconium oxides were discussed at two of the meetings. Judging from the rest of the program, subjects that interest steelmakers these days (other than stainless steel) include physical chemistry, foundry practices, direct reduced iron as a furnace charge, cost reductions, electrode holders, and special techniques. C.R.W.

Table I — Stainless Steels for Exhaust Valves

Code	Type	C	Mn	Si	Cr	Ni	Other
XB	ferritic	0.80	0.60	2.0	21.0	1.6	—
XCR	sigma-hardening	0.50	1.0	1.0	24.5	5.0	2.5 Mo
21-12	austenitic	0.25	1.0	1.0	21.0	12.0	—
21-4N	austenitic	0.45	0.9	0.25	21.0	4.0	0.45 N

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On the evening of November 28, 1958, a 100-ton ATLAS lifted from its pad at Cape Canaveral and arched majestically into the heavens. 30 minutes later its nose cone shot into the Atlantic, marking the first successful completion of its fully-programmed distance of 6300 statute miles.

The main part of the ATLAS structure is literally a huge fuel tank, the shell of which is thin gauge MicroRold stainless steel. Important factors in selection of stainless steel for the outer skin of the ATLAS are—great strength at both high and low temperatures, resistance to corrosive exotic fuels and good workability.

The stainless skin, supplied exclusively by Washington Steel, requires extremely close control of mechanical properties and gauge tolerance which are regularly produced through Washington Steel's long experience with precision rolling equipment.

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Modern Machining Methods

Digest of seven papers presented at the William Park Woodside Panel Conference sponsored by the American Society for Metals during the National Metal Congress, Cleveland, October 1958.

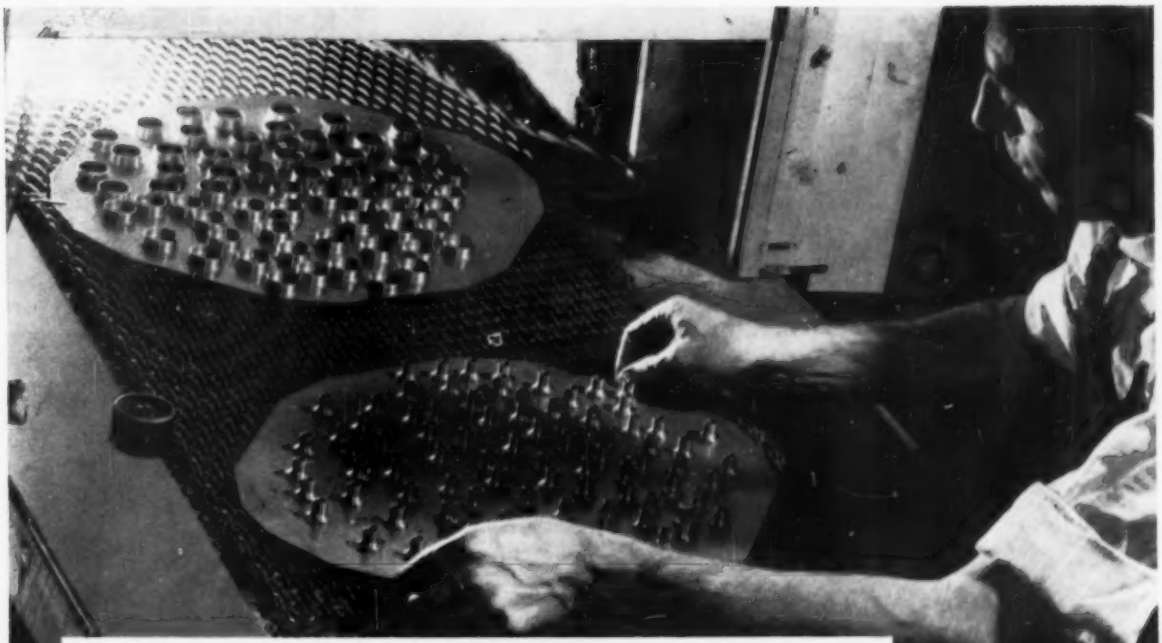
ADVANCES are being made in practically every phase of machining. New designs, materials and tools all aid in the race for increased production at reduced cost. The seven papers presented at this conference describe many advances along several fronts.

New Tool Materials

Robert T. Hook, Warner and Swasey Co., opened with a discussion of new cutting tool materials. His experience, based on controlled experiments and job-lot operations, indicates that all of the common tool materials have been significantly improved during the last few years. Some tools made of the new super high speed steels last 50 to 100% longer (for equivalent cutting rates) than regular T-1 tools. Vacuum sintered, tungsten carbide tools are tougher than conventional carbide tools, permitting appreciably faster speeds. With the newer carbides, cutting speeds can be raised 40% on steels of about Brinell 195, or 20% on steels of about Brinell 340. They also permit increases of about 50% on cast irons. Despite their higher price, Hook found that total cutting costs were lowered about 5%.

Since 1952, improvements in carbides containing both titanium and molybdenum have permitted doubling the cutting speeds normally used with C-8 carbides on 0.45% carbon steels. However, tools made from mixed carbides are more prone to chipping and more difficult to braze than tungsten carbide tools.

Hook's experiments indicate that ceramic (alumina) tools made by



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Machining . . .

four European and one American manufacturer are of comparable quality. In his tests (at about 975 ft. per min. on A 4150 steel) longer lives were obtained on tools ground to shapes common in American practice. At around 1500 ft. per min., however, more metal could be removed by tools with the positive rake angles and high (20 to 60°) side-cutting edge angles recommended by Russian investigators. He concluded that ceramic or oxide cutting tools are best suited for uninterrupted finishing cuts, for abrasive materials such as cast iron, and for steel workpieces with hardness over Rockwell C-40.

Constant Speed Machining

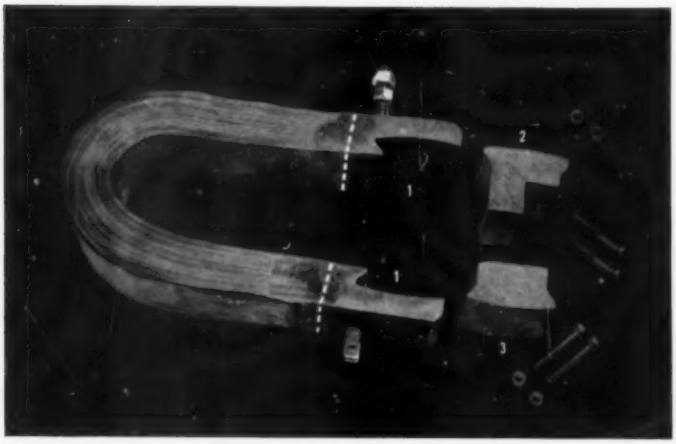
A lecture by Milton C. Shaw, Metals Processing Div., Massachusetts Institute of Technology, concerned the advantages of machining at constant speed. By adjusting the spindle speed according to the radius being cut, surface finishes and production rates can be improved. Shaw, by developing an analytical method for comparing the effects of variable speeds with those of constant speeds on machining, can also estimate whether or not the cost of providing stepless, speed-changing on a machine tool will be a good investment.

In many instances, the savings from machining at constant speed are greater than those estimated from cutting time alone. Ordinarily, benefits are more substantial for facing cuts and for large boring mills than for straight turning operations. From the cost standpoint, it is better to use the optimum constant speed with high speed steel tools than with carbide tools. Cost savings are least pronounced for oxide tools.

Preset Tooling

A. S. Rogers of the Wesson Co. described the advantages of quick-change, preset tooling for high-production machining operations. For example, heads containing 5 to 10 drills make it unnecessary to change and adjust individual tools. Preset tooling is becoming more widespread because the time required for changing and setting tools may account for 75% of the downtime on many production lines. As an example,

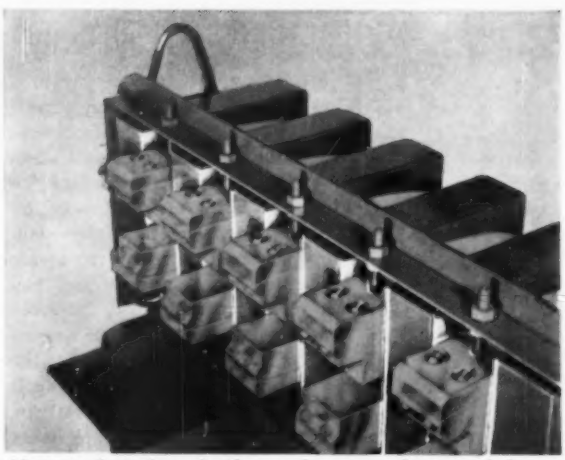
$70 COST CUT for each electrode assembly—through use of Anaconda extruded copper shapes—helped Frank C. Cheston Co. add replaceable contact feature in its line of electric rivet heaters.



Electric rivet heaters are tough, simple machines that have for years been saving time and money in riveting operations. But Frank C. Cheston Co., Newark, N. J., saw a chance to save its customers some money in maintenance, too, by making electrode-assembly contacts easy to remove for resurfacing or replacement.

Originally these contacts were integral with the laminated copper conductor forming a one-turn secondary in the step-down transformer. In redesign, only parent blocks (1, at left) are welded to the conductor. Contact shoes (2 and 3), which mate precisely with parent blocks for unimpaired conductivity, are easily removed by unbolting*.

Machining pieces 1, 2, and 3 from copper bar stock ran costs so high that the price of the heater would have become unrealistic. American Brass specialists were consulted and precisely shaped extrusions of high-conductivity copper were produced, from which the finished sections are cut. Tolerances were closer and surfaces finer than with machining—and costs per electrode assembly were cut $70.



Close-up of a 5-electrode Cheston electric rivet heater with the new removable contact feature for easier maintenance. Savings from use of Anaconda extrusions enabled Cheston to include this new feature at practically the same price as heaters of previous design.



Cheston electric rivet heater in use showing how step-design of upper contact (2, in illustration above, left) makes it easy to heat both long and short rivets. Contacts are opened by foot pedal and contact pressure is maintained by springs seen just above the pedal.

**Bolts are of Everdur®, Anaconda copper-silicon alloy.*

CUTTING shop costs may be easier than you think. Take a fresh look at the way you're making metal parts. Make a note of any part you suspect might benefit by the use of extrusions, special-shaped tube, die-pressed forgings, etc. Then call in your American Brass Company representative and talk it over with him. He will see that your problem gets to the right Anaconda technical specialists promptly and will expedite the answer. Or write: The American Brass Company, 14900 Garfield Ave., Paramount, Calif. In Canada: Anaconda American Brass, Ltd., New Toronto, Ontario.

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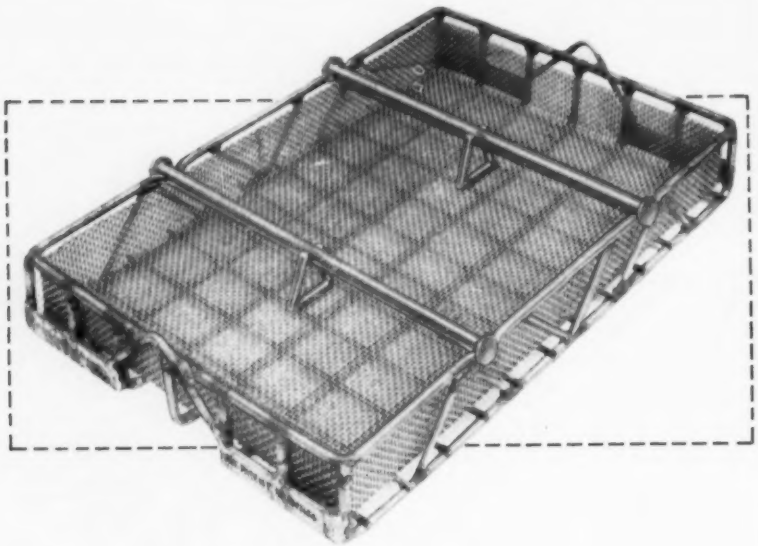
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of furnace tray performance



Originated by Rolock engineers, and now covered by patent, the unique construction of these round-rod sled-type trays has proved so successful that an increasingly large number of them are in service in Ipsen, Lindberg, Hevi-Duty, Surface Combustion and other furnaces with this type of hearth.

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These trays clearly demonstrate the following important advantages in service:—

- Travel easily and smoothly over hearth, with bottom bars acting as sleds.
- When used two-high, stacking bars provide adequate support and also prevent side-slide.
- Live-load to basket weight ratio often better than 10 to 1.
- All-Inconel construction with Rolock-quality precision pressure welding.
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- Lowest cost per hour of use.

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Machining . . .

one organization reduced the change-and-set time for a large complicated milling cutter with inserted blades from 15 hr. to 45 min. by adopting quick-change, preset tooling.

Preground, throwaway tool bits are the simplest examples of this type of tooling. They are useful for maintenance machining operations, small-lot runs, as well as for almost all high-production operations. In addition to lowering tool costs directly and minimizing idle time, they can provide savings from smaller inventories.

Mr. Rogers pointed out that potential application for preset, quick-change tooling can be recognized by the following symptoms:

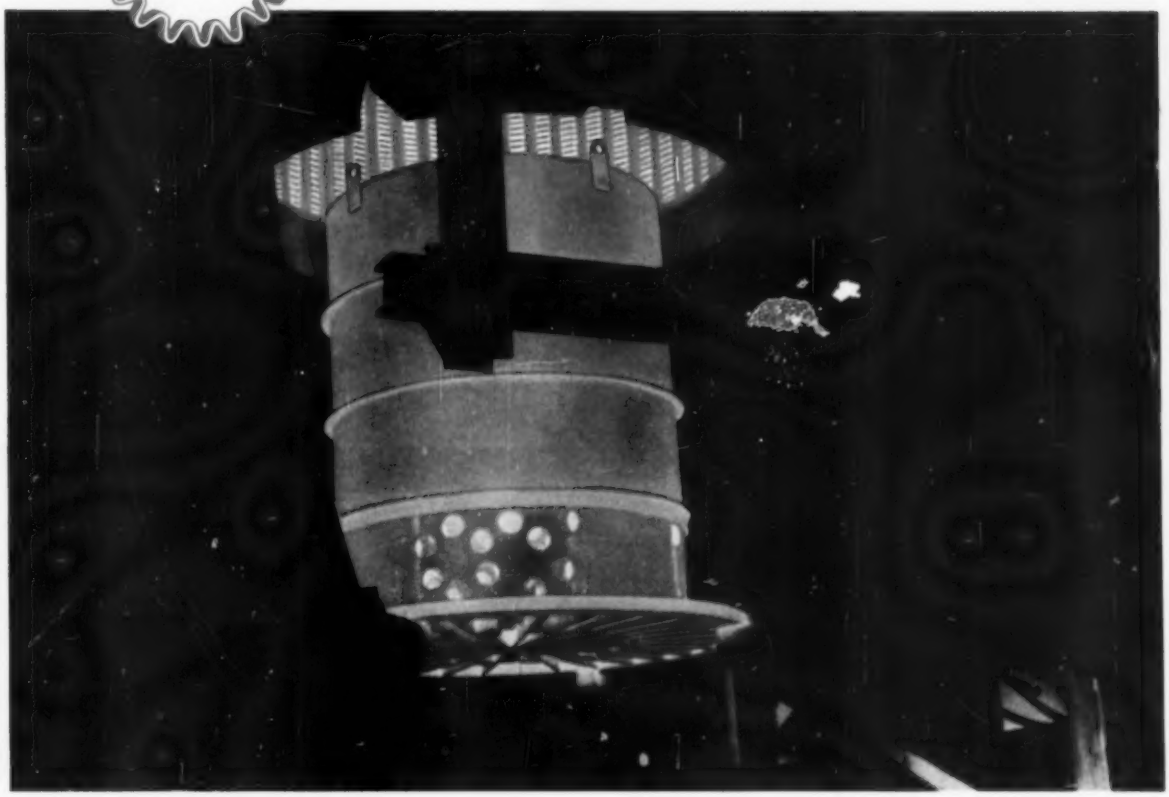
1. High ratios of setup to machining time.
2. Unusually frequent tool changes.
3. Repetitive accuracy is important and gaging is frequent.
4. Multiple cutting tools are used.
5. Changes in machining conditions have been made to increase productivity.

High-Speed Machine Tools

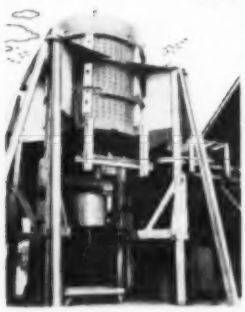
M. S. Curtis (Warner and Swasey Co.) reported on trends in high-speed machine tools. Many plants are using higher cutting speeds than normal to secure better surface finishes and faster rates of metal removal. However, the faster cutting speeds permitted by recent improvements in workpiece and tool materials have multiplied the problems of the machine tool builders.

Satisfactory performance at the higher speeds requires machine tools with greater accuracy and rigidity, larger power supplies, and better bearings. It usually takes almost three times as long to accelerate to 50% higher speeds; therefore, high-speed machine tools require much larger motors to reach operating speeds quickly enough to avoid overheating. For example, a turret lathe ordinarily equipped with a 7.5-hp. motor needs a 15-hp. motor if the maximum spindle speed is increased from 1300 to 1600 rpm. There are also problems in maintaining lubricating films; furthermore, accuracy is impaired if bearings or spindles heat up in service. For reasons such as these, Mr. Curtis concluded that

KANTHAL heating elements



...again selected by PACIFIC SCIENTIFIC for gigantic SOLAR honeycomb brazing furnace



BIGGEST YET! This unique elevator type brazing furnace is the only one of its kind in existence today. Towering 35 feet high, inside dimensions 8 feet by 10 feet, loading capacity of 4000 pounds, power input of 610 KW. Numerous new features enable the furnace to braze, on a production basis, honeycomb panels that will withstand 1600° F. continuously and 2000° F. intermittently.

This unusual furnace built for Solar Aircraft by the Pacific Scientific Company of Los Angeles met rigid design specifications in order to provide extremely close temperature uniformity with fast heating and cooling. Met them so well – in fact – that Solar ordered another similar furnace.

And in both furnaces – KANTHAL A-1 RODS were selected for the heating elements. According to Pacific Scientific . . .

"Kanthal Rods provided the ideal elements for these honeycomb brazing furnaces. A protective oxide film produced by aluminum in the rod alloy at the elevated temperatures permits the wire to give extremely high temperatures for long periods of time without failure when operated in an air atmosphere. Kanthal A-1 elements were used because of their ability to work at these elevated temperatures and to provide excellent service life."

These two Pacific-built Solar furnaces are among the largest KANTHAL installations of rods. Their satisfactory performance is the result of constant KANTHAL research to provide engineers with a broader and better means to solve heating and resistance problems.

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Machining . . .

the limiting speeds for lathes have probably been reached unless bearing, lubricating, and cooling systems are changed drastically.

Shorter floor-to-floor machining cycles are more likely to come from other changes in practice such as:

1. Speeding the traverse and approach mechanisms.
2. Feeding parts semiautomatically or automatically.
3. Locating controls for more convenient use.
4. Employing quick-change, preset tooling.
5. Using tape or numerical-type automatic controls.

Forming Methods

R. D. Halverstadt and R. Cogan of General Electric Co. discussed roll forming and electrical machining methods. High-temperature alloys can be roll formed, with cold working ordinarily producing higher strengths with little change in ductility. Sheets have been flow-turned to finished parts which were formerly made as weldments.

Electrical discharge machining has some drawbacks. For example, when a surface roughness of 40 micro-in. was produced, cracks 0.002 in. deep appeared in workpieces of alloy A-286. Tensile residual stresses were 20,000 psi. at the surface, and zero about 0.020 in. below the surface. Parts machined by electrical discharges had a fatigue less than half that of parts machined by conventional processes.

The speakers also described some of their studies on electrically assisted grinding operations with resin-bonded wheels. When direct current was applied between the wheel and the workpiece, average shaft-horsepower consumption was lowered from 25 to 3 hp. for the conditions investigated. However, energy consumption was so great that total power requirements were much greater than for the conventional process. Electrolytic grinding produces good surfaces on A-286, and wheel wear was considerably less than normal.

Machining High-Strength Steels

R. W. Runyan (Menasco Manufacturing Co.) related his experiences in



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Machining . . .

machining steels at high strength levels. Steels of 295,000 psi. (Rockwell C-56) have been machined in production operations; steels of 350,000 psi. (Rockwell C-65) have been cut in the laboratory. Most of the part produced by Menasco require interrupted cuts, and are characterized by odd shapes and eccentric masses. For these reasons, high speed steel tools are usually employed though permissible cutting speeds are slow, around 30 ft. per min. Feeds range from 0.006 to 0.010 in. per revolution, and cut depths are usually 0.015 or 0.030 in.

Taps, drills and reamers are made from M-7 toolsteels. If made with specially designed webs, spiral angles and notch pitches, they last for 10 to 25 holes when working on 240,000-psi. parts. In such applications, reamers are used at speeds of 30 ft. per min. with feeds of about 0.018 in. per revolution. Several special grades of cemented carbide tools permit cutting at speeds of 180 to 200 surface ft. per min. on 290,000-psi. steels. This, and other experience, led Runyan to conclude that further improvements in cutting tools, rather than in machine tools, are most likely to improve production rates.

Machining Molybdenum

The final paper of the conference, by H. J. Siekmann and L. A. Sowinski of General Electric Co., covered the machining of arc-cast molybdenum. The high scrap value of molybdenum chips frequently influences the choice of cutting conditions. For example, tools with chip breakers or negative rake angles are ordinarily undesirable because they result in higher temperatures and excessive oxidation of the chips. To avoid contamination, cutting fluids were not used in the study, but cooling the tool with an air blast proved to be helpful.

The speakers found that carbide tools would last 20 to 30 min. at cutting speeds of 300 to 350 ft. per min. Best results were obtained with the cobalt-bonded tungsten carbide types ordinarily used for cutting cast iron and nonferrous metals. Steel cutting grades are less satisfactory because of their inferior toughness. Feeds of 0.005 to 0.010 in. per revolution are ordinarily used; heavier feeds can cause minute chipping at the cutting edge. Chipping and "build-up" persisted to speeds up to 600 ft. per min. Rake and lead angles of about 15°, relief angles of 7° and nose radii of 1/32 to 1/16 in. proved satisfactory. Honing the cutting edge of the tool helps to prevent chipping.

F. W. Boulger

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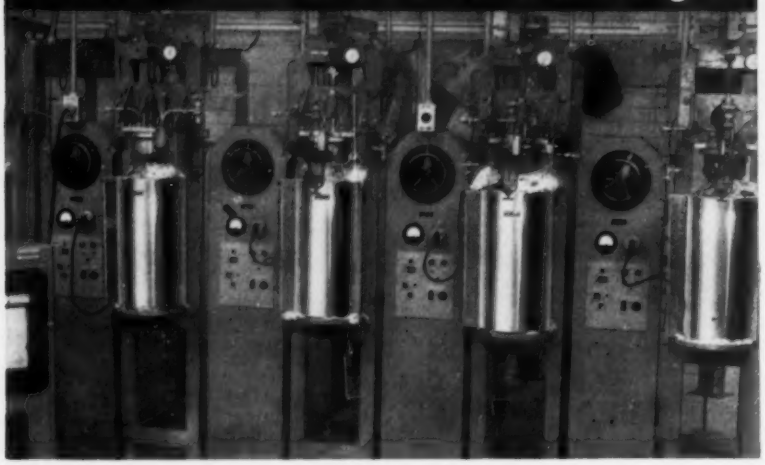
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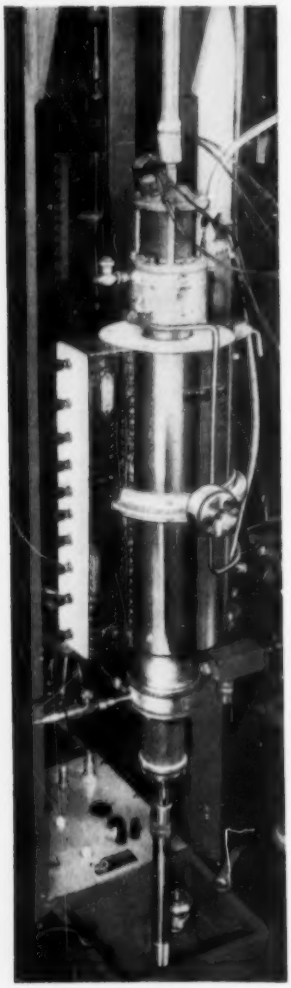
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Liquid-metal creep testing frames (shown at top) Creep testing in various gaseous environments (left)

Removal of Sulphur From Hot Metal

Digest of "Desulphurization of Hot Metal—A Production Evaluation", by A. J. Deacon, D. B. Powell and E. C. Rudolphy. Presented at 41st A.I.M.E. Openhearth and Blast Furnace Conference, Cleveland, April 1958.

While the presence of sulphur in hot metal does not appear to affect openhearth performance, its removal by external methods after tapping from the blast furnace would lead indirectly to operating economies and increased production. An opportunity to operate on a reduced flux burden is offered (since there is no attempt at desulphurization in the furnace). A reduction in coke rate and an increase in iron production is then possible.

For the experiment, 82,000 tons of hot metal from two blast furnaces were desulphurized over a 92 day period. Reduction of sulphur from 0.053 to 0.033% (these are averages) was accomplished by pneumatic injection of a 4:1 calcium carbide-calcium oxide mixture, finely ground and conveyed by dry nitrogen. To avoid delays, injection was started when the first ladle was filled, and timed according to this table:

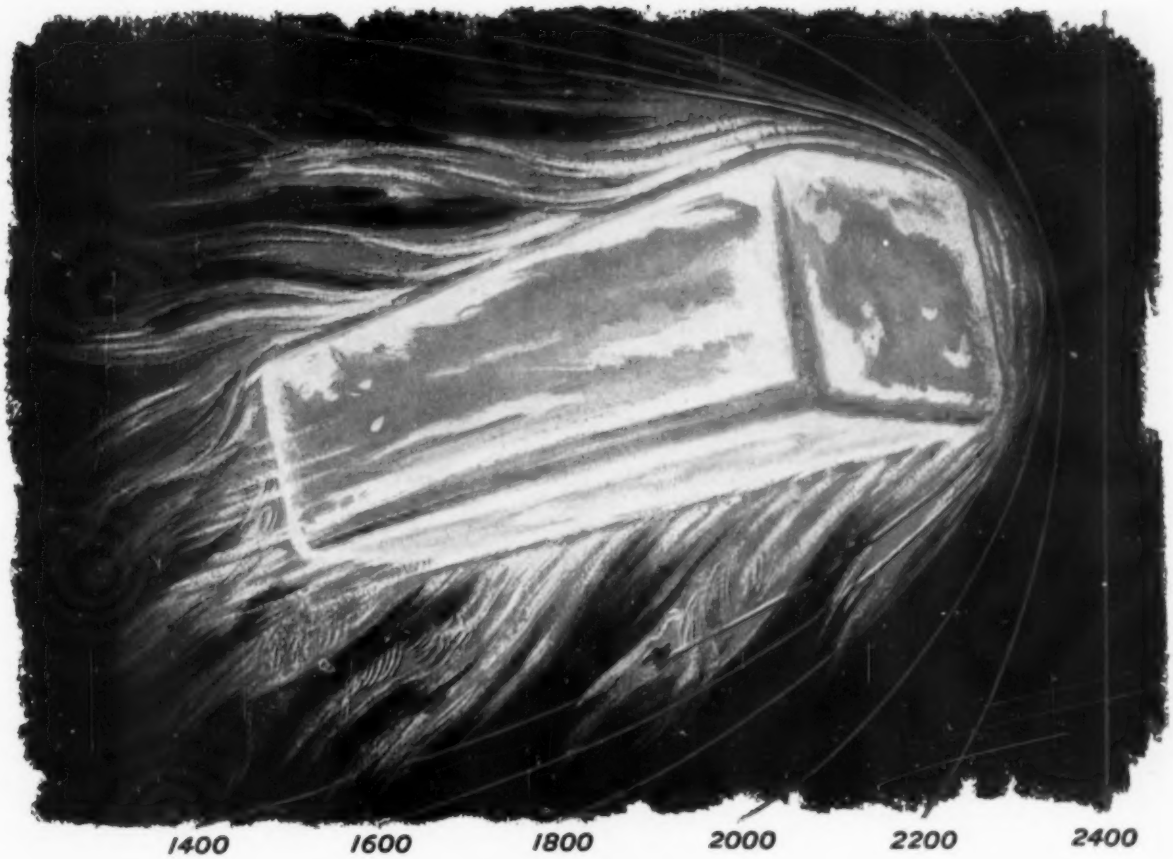
Estimated Sulphur	Treating Time
0.040%	5 min.
0.050	10
0.060	15
0.070	20
0.080	25
0.090 and over	30

Injection continued as successive ladles were filled, times being adjusted if estimated sulphur variations were sufficiently severe. An average of 5.6 lb. of calcium carbide was used per ton of hot metal treated; this represents an efficiency of 18.2%.

The performance of the blast furnace with reduced flux and the performance of desulphurized hot metal in the openhearth were analyzed.

In general, it was concluded:

1. The technique could be applied to routine production of hot metal.
2. Blast furnace production increased from 2.9 to 5.5%, while coke rate decreased about 3.75%.
3. The materials cost of desulphurization was from 35 to 40¢ per ton of hot metal; net savings per ton ranged from 0.3 to 1.5%. C.R.W.



Bending the Heat Barrier



Specialized mill equipment is available at HAYNES STELLITE for rolling high-temperature alloys into a variety of shapes and sizes. Bar (above) is being produced on a 24-inch mill.

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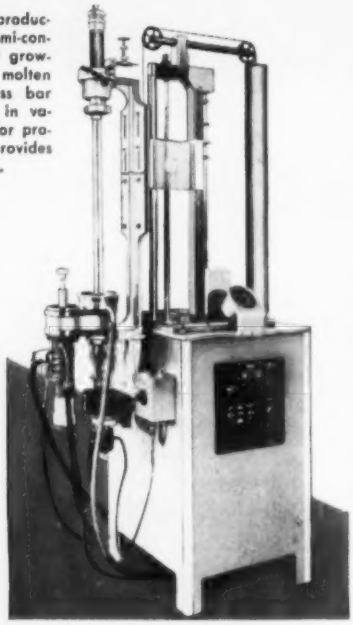
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Foundry Activities in France

Digest of "Foundry Research in France", *Metal Industry*, Vol. 90, June 7, 1957, p. 485-487.

THE ANNUAL PRODUCTION of the foundry industry in France amounts to some 2,000,000 tons, including brass, bronze, cast iron, steel and light metal alloys. It employs about 100,000 people in some 2000 foundries. The majority of the foundries are small.

All the foundries formed, on a collective basis, a central institute called the Centre Technique des Industries de la Fonderie, its main concern being technical development. Maurice Olivier, president of the General French Foundry Trade Assoc. is also the presiding officer of the Institute, the director of which is A. Le Thomas. All foundries contribute on a basis of 0.4% of their turnover. No further charge is made.

The institute has as its object "the advancement of mechanical progress, the participation in improvement of productivity, and the insuring of quality". Technical assistance to individual foundries absorbs one half of the budget, the other being devoted to research. There is a research laboratory at Sevres and ten regional laboratories located at strategic points. In addition to this, there is a group of highly specialized consulting engineers, who are available to visit any foundries in need of assistance. Some 400 to 500 problems per month are taken care of in this way. The solution of the problem of one foundry is made available to all.

Besides these activities there is a division devoted to basic research. This work is developed at the Sevres laboratory, whose grounds cover approximately 48,400 sq.ft. It is said to be the most extensive laboratory of this type in the foundry field, including as it does classical and modern apparatus for metal. physics and chemistry and, most important of all, a highly trained group of metallurgists.

The institute has developed a number of standard specifications which have received official acceptance and are now in use. A library of some 15,000 volumes and

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Foundry . . .

translations of 4500 foreign articles has been collected. The institute publishes two foundry journals, *Fonderie* and *Journal d'Information Techniques des Industries de la Fonderie*. These publications have a very large circulation in France and abroad.

H. J. ROAST

Mill Sampling of Ship Plate Steel

Digest of "Mill Sampling Techniques for Quality Determination of Ship Plate Steel", by Charles L. Staugaitis. Report No. SSC-106, Ship Structure Committee, Jan. 31, 1958, 44 p.

IN ORDER to obtain information on the variation of mechanical properties within typical heats of currently produced ship plate steel, 54 plates from six heats were obtained from two producers, U. S. Steel Corp. and Bethlehem Steel Co. The former contributed 27 plates of ¾-in. American Bureau of Shipping (ABS)-Class B, and the latter contributed 27 plates of 1¼-in. ABS-Class C steel plate. All were made to the American Bureau of Shipping specification in effect prior to Feb. 1, 1956. A sample of 24 plates provided data on the variations among plates, ingots and heats. Five additional plates were subsequently tested to resolve doubtful cases. Although primary interest was on the notch toughness characteristics, the static tensile properties, ferrite grain size and chemical composition were also measured. In addition, the severity and extent of segregation in some of the plates and the influence of segregation on impact test results were studied.

Analysis of 29 plates indicates that the mechanical properties of plates in an entire heat can be satisfactorily evaluated by tests on two properly chosen sample plates.

Little variation was found in the properties of plates from the edge to the center, although considerable segregation occurred. Large differences were encountered between top and center sections and between sections of the ingot. The Charpy impact values were about 40° F. for

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Ship Plate . . .

the Class B steel or 15 ft-lb. energy absorbed. This was the transition temperature for this grade of steel. The Charpy impact values for the Class C steel were −20° F. for 25 ft-lb. energy absorbed and −30° F. for 15 ft-lb. energy absorbed.

While emphasis during the initial phase of this investigation was on the development of a sampling scheme suitable for future testing of many heats, some consideration was given to the problem of relating mill variables to properties. However, examination of the mill data sheets showed that both mills employed rather uniform practices in the production of these heats; and, consequently, studies of such relationships were deferred until a greater variety of data is available.

A statistical evaluation of the results obtained on these steels indicates that selection of at least two plates from the same ingot would provide satisfactory information on the characteristics of a heat. However, as pointed out in Appendix A, it would be desirable to test an additional plate from the same ingot and thus allow a better evaluation of the uniformity of the heat.

Finally, the remarks below should provide a guide for future sampling of heats. Ingot identity is unimportant (with the possible exception of first and last ingots, which were not included in the scope of this sampling program). Plate position within the ingot is important. The general level of a property is well represented by a plate from the center of an ingot. Extreme values, if present, occur chiefly in top plates. The decision to include a top plate in sampling a heat depends on the importance attached to detecting the existence of plates most divergent from the general average.

The statistical analysis points to less variation between plates from comparable positions in *different* ingots than is found between plates from different positions in the *same* ingot. Visual observation of segregation confirms this view. It was found that, for the B steel, segregation was present in all top and center plates and very slightly in one bottom plate. Faint segregation was observed in two of the three heats



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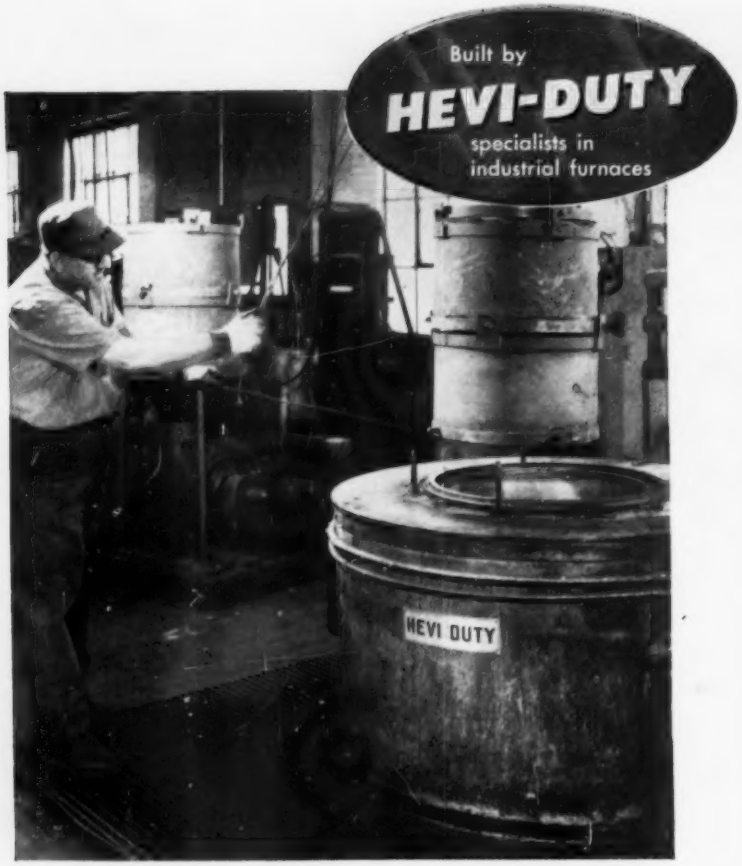
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Ship Plate . . .

of C steel and then only in the top and center plates.

Not less than two plates should be taken to characterize a heat of steel. They should be from the same ingot. A pair of locations such as top and center (or top and bottom) of the ingot will be most likely to bring to light lack of uniformity in the product. Uniformity is as important as the average in evaluating the product. Three plates, rather than two, from the same ingot would double the information on uniformity. If the scope of the investigation permits, three plates are recommended to characterize a heat of steel.

E. C. WRIGHT

Strain-Age Embrittlement

Digest of "The Nature of Strain-Age Embrittlement", by C. J. Osborn, *Journal*, Iron and Steel Institute, Vol. 188, February 1958, p. 97-101.

THE CHANGES which occur in steel during aging after plastic deformation can be studied conveniently by means of notched-bar tests or by means of hardness measurements. Most investigations of the past, including the theoretical treatment by Cottrell and his collaborators, have dealt primarily with strain-age hardening which is assumed to be directly associated with the strain-age embrittlement that manifests itself in an increase of the impact energy transition temperature. The author of the present study has aimed to show that both processes, namely, hardening and embrittlement, are merely different manifestations of the same structural changes occurring during the strain-aging cycle.

The material chosen for this work was a soft magnetic iron (0.025 C, 0.02 Mn, 0.008 N, 0.034 S, 0.017 P, 0.007 Si) which was fabricated into slightly oversized Izod bars. The bars were plastically strained 5% to a standard 0.394-in. square section and immediately notched, machining being completed 10 min. after straining. Except for a few control curves, all impact testing was done at 30° C. at which temperature the impact energy value was found to be very

Embrittlement . . .

sensitive to the progress of the aging reaction. The aging temperature baths were held at 20, 30, 45 and 80° C.

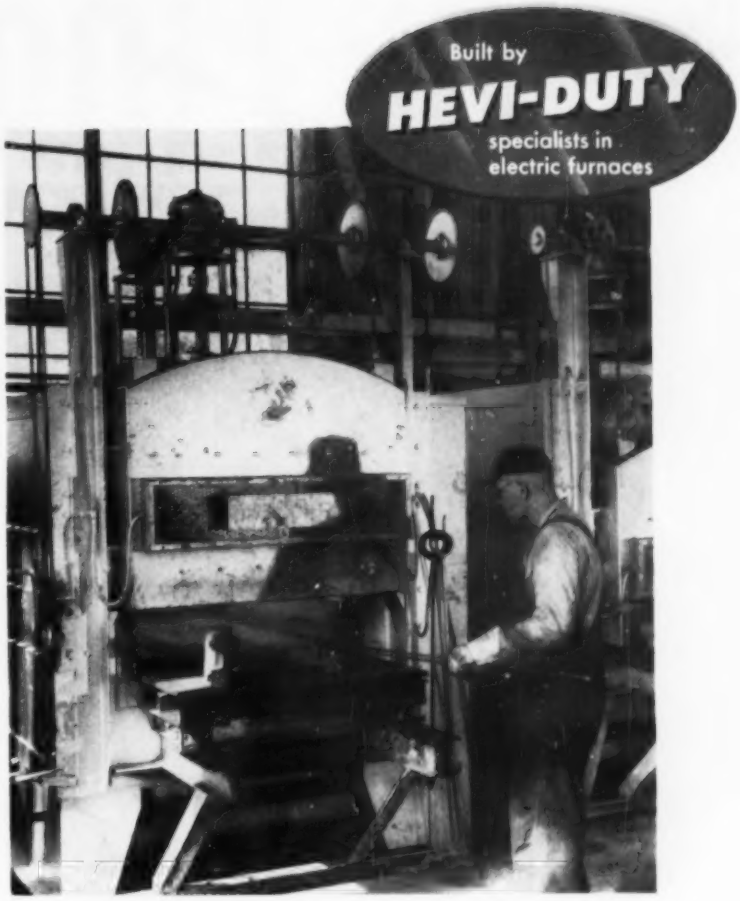
The results of this investigation as well as results of earlier investigations appear to be consistent with the notion that strain-age hardening and strain-age embrittlement are simply different manifestations of the same fundamental process. The process itself appears to be initiated by the strain and activated during the subsequent time at which the specimens are held at the aging temperature. Such data are usually represented by a graph of log aging time versus inverse of aging temperature from which the activation energy Q can easily be determined. The author presents such a graph for the aging time and aging temperatures required to reduce the impact energy to two arbitrarily selected values of 12 and 15 ft-lb. The calculated activation energy values are 18,100 cal. per mole and 23,100 cal. per mole, respectively. Within the limits of experimental accuracy, these values of Q agree with activation energies deduced from previously reported strain aging studies such as hardness measurements, stretch-strain observations, rate of return of yield point, magnetic and elastic after effect, change in electrical resistivity during aging, change in internal friction with strain aging, as well as with the activation energies for diffusion of carbon and nitrogen in ferrite.

F. Forscher

Bonding of Polyethylene to Metals

Digest of "Bonding Polyethylene to Rubber, Brass and Brass-Plated Metals", by H. Peters and W. H. Lockwood, Monograph 2932, Bell Telephone System Technical Publications.

Bonding polyethylene to rubber, brass or brass-plated metals can be done using a cement based on partially hydrogenated polybutadiene (8% unsaturation), known as "Hydropol", made by the Phillips Petroleum Co., Bartlesville, Okla. This polymer, compounded with



Byron Jackson Division, Borg-Warner Corporation, hardens and tempers high-strength components for oil well tools in this Hevi-Duty box furnace

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Bonding . . .

vulcanizing ingredients, is inserted between polyethylene and brass, in the form of a thin film. Application of heat and pressure produces a strong vulcanized bond.

The bond between partially hydrogenated polybutadiene and compositions of soft and hard rubber is believed to be formed primarily by vulcanization, involving the double bonds in both molecules. Even a small amount of unsaturation in partially hydrogenated polybutadiene suffices for a strong bond. For example, hydrogenated polybutadiene, mixed with enough polyethylene to produce a compound with 3% unsaturation, still gives a satisfactory bond.

Various ingredients are added to partly hydrogenated polybutadiene to make it capable of vulcanization. Apparently the partly hydrogenated polybutadiene heat-seals to the polyethylene because of its similar chemical structure. The bond to a vulcanizable rubber is probably due to the formation of sulphur cross-links at the interface that takes place during vulcanization.

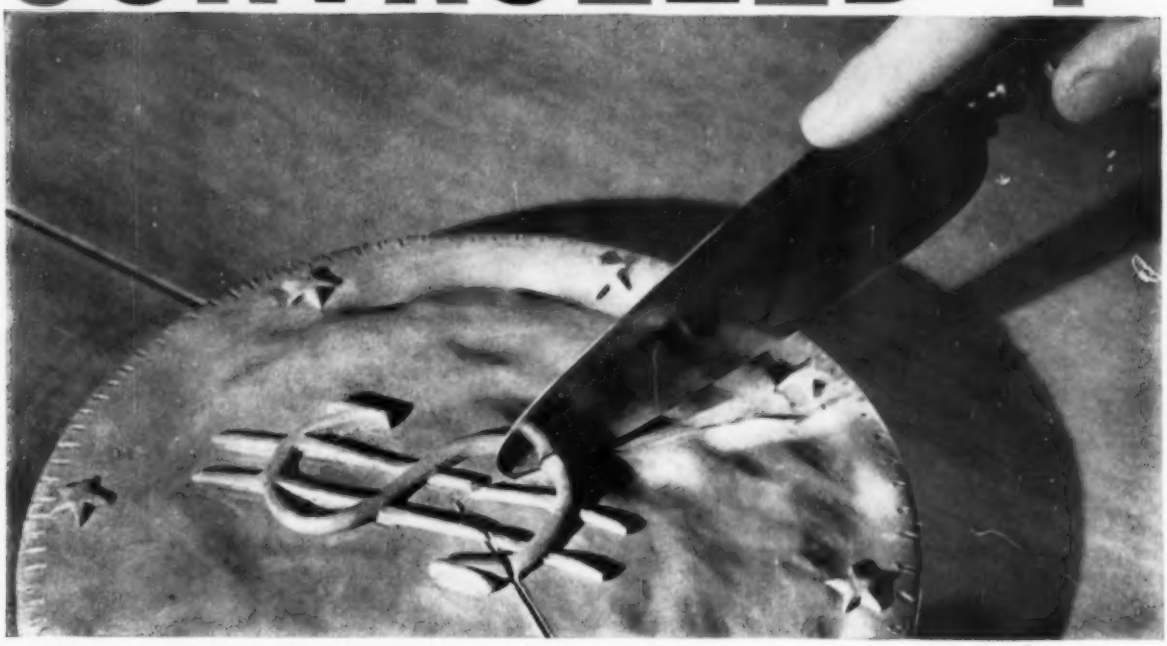
Bonding to brass is accomplished through the accepted theory of selective sulphiding of the metal. Brass with a copper content of 65 to 75% gives the best bonds. Polybutadiene with 3 to 30% saturation appears to give the best adhesion.

A layer of bonding agent, 2 to 3 mils thick, is desirable for proper adhesion. The bonding agent may be dissolved in a solution and sprayed, brushed or dipped to provide the desired layer, or a thin sheet can be fabricated and inserted between the materials to be bonded. Bonding is accomplished at temperatures ranging from 150 to 232° C. and at pressures of 100 lb. per sq. in. or less, although higher temperatures and pressures may be used.

Some of its major applications may be the bonding of polyethylene insulation to wire and cable, printed circuit boards, submarine cable repeaters, coatings for tank linings and plating racks, and various missile uses. The process gives bonds with tensile strengths up to 1000 lb. per sq.in. and peel strengths ranging from 60 to 100 lb. per sq.in.

A.G.G.

CONTROLLED "T"®



CUT YOURSELF A SLICE OF *profits!*

If you now use hard (chilled) iron abrasives—and almost half of all abrasives used still fall into this category—may we suggest **CONTROLLED "T"®**, with its exclusive and unique properties?

No doubt you selected hard iron abrasives because you wanted: fast cleaning and cutting action (the ability to remove sand and scale) and the "keying" action (where the product will receive further processing). Disadvantages of ordinary chilled shot and grit, of course, lie in their rapid breakdown (causing high consumption) and in their extreme high hardness (causing excessive wear on blades, control cages, impeller, liners, etc.)

CONTROLLED "T"®, made to a specific BHN, is an "iron fist in a velvet glove." Its controlled specifications are such that you enjoy the speed and cutting action of chilled, without the disadvantages of rapid breakdown and high maintenance costs. Savings: as much as 50% on consumption, as much as 40% on maintenance! You can cut yourself a generous slice of profits with these important cost-cutting features of **CONTROLLED "T"®**. If this sounds like a fairy tale, try us! We won't upset your operations with a test, there is a simple and inexpensive way to tell. Cost-conscious customers have been enjoying these extra profits for over a decade!

If you are using ordinary annealed or steel abrasives, you'll want to try our **PERMABRASIVE®**, the pearlitic malleable shot and grit with a controlled hardness range that saves you money through faster cleaning and lower cost per ton. Or **PERMASTEEL®**, the low cost "work-horse" of the long-life abrasives, may fit your special application perfectly to produce many of the same cost-cutting advantages.

FREE: *the* NEW *"Second Reader on the use of shot and grit." Write for your copy.*

Sold Exclusively by
HICKMAN, WILLIAMS & COMPANY (Inc.)
Chicago · Detroit · Cincinnati · St. Louis · New York · Cleveland · Philadelphia · Pittsburgh · Indianapolis

Exclusive West Coast Subdistributors
BRUMLEY-DONALDSON COMPANY
Los Angeles · Oakland

NATIONAL
METAL ABRASIVE COMPANY
3560 Norton Rd. • Cleveland 11, Ohio
Western Metal Abrasives Co. (Affiliate)
101 E. Main Street • Chicago Heights, Illinois
Sole manufacturers of
Permabrasive® and Controlled "T"® abrasives.

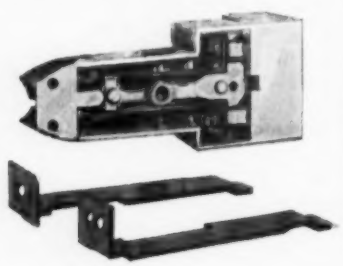


CONTACT!

NEW "CONTACT BRONZE" STRIP KEEPS THE SPRING IN FORMED CONTACT PARTS, YET COSTS UP TO 25% LESS!

Manufacturers can now form intricate contact parts that cost less from Bridgeport's new "Contact Bronze" strip. High quality is maintained in this new, red color alloy strip by the addition of a minute quantity of phosphorus, which provides superior spring properties, even in hard-to-form parts.

Specially engineered for the electronics industry, Bridgeport "Contact Bronze" Alloy 92 costs up to 25% *less* than metals previously used for this application. If you form or stamp shaped contact parts, learn how "Contact Bronze" can maintain quality at lower cost. Samples and a copy of the "Contact Bronze" data sheet are available from your nearest Bridgeport Sales Office. Call or write today!



These electrical terminals were originally made of phosphor bronze. Parts now are produced from Bridgeport "Contact Bronze" 92—at appreciable savings.



American Electric Switch Division, Clark Controller Co., Cleveland, Ohio, wanted a lower-cost material for pressure clips. Bridgeport "Contact Bronze" 92 met all specifications . . . good electrical conductivity to reduce heating, superior spring and mechanical properties—and all at lower cost.



A leading manufacturer of control switches needed these fuse clips with special mechanical and electrical properties. Bridgeport "Contact Bronze" 92 met the specifications—at lower cost.

BRIDGEPORT BRASS COMPANY

Bridgeport Brass Company, Bridgeport 2, Conn. • Sales Offices in Principal Cities

Specialists in Metals from Aluminum to Zirconium

Metal Progress

Bulletin Board...

The Buyers Guide For Metals Engineers

the GRIES

MICRO-REFLEX HARDNESS TESTER

Leads: 10 to 3000 gram with CARL ZEISS Optical System

Measurement: to 0.0001 mm. . . . Observations on Ground Glass . . . Projection: to 0.001 mm. . . . Many Unique, Very Important Features.

INVESTIGATE!

Write for Bulletin No. A-16



GRIES INDUSTRIES, INC.
Testing Machines Division
NEW ROCHELLE 3, N. Y.

LIST NO. 135 ON INFO-COUPON PAGE 169

METAL POWDER PARTS / UNUSUAL SHAPES

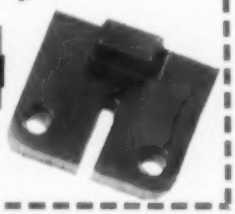
carburized tensile strength to 200,000 psi.



Supermet specializes in powder metal parts requiring extreme physical properties and/or unusual intricacy. Controlled carburized case plus new approaches to die design bring you steel parts with the economy of powder metallurgy. In electrolytic iron, 7 ranges of properties are available; ask also about stainless steel parts. As an indication of capability, a counter pinion (*) is currently produced with tooth extensions which withstand a 60 lb. load. Previously the part could only be made by machining; now it is fabricated at a 25% saving by the Supermet process. Send your part print today.







SUPERMET DIVISION

GLOBE INDUSTRIES, INC.

1467 Cincinnati St., Dayton 8, Ohio

free technical literature

LIST NO. 174 ON INFO-COUPON PAGE 169

HUPPERT ELECTRIC FURNACES AND OVENS

for Laboratory and Plant



BENCH MODELS

- Range: 300°F. to 2000°F.
- High temperature, heavy-duty Kanthal elements
- Multi-insulation
- Counter-weighted, tight-sealing door
- Operational pilot light
- Shipped ready to operate

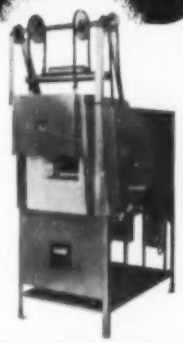
Model No.	Inside Dimensions			KW	Prices 220 Volt Single Phase	
	Wide	High	Deep		With Huppert Input Controller	With Electronic Prop. Controller
869	8"	6"	9"	4	$296.00	$480.00
11*	8"	6"	12"	4	306.00	518.00
12*	8"	8"	12"	6	382.00	590.00
12A*	8"	8"	18"	9	490.00	698.00

*For 2300°F. add $95.00 to No. 11 and No. 12, and $105.00 to No. 12A. No. 12A can be furnished for 3 phase at no additional cost. For floor model add $52.00 to above prices. No. 869 standardly supplied for 2200°F.

FLOOR MODELS
28 Standard Sizes

- Continuous operation to 1850°F.—intermittent to 1950°F.—for 2300°F. on special order.
- Complete with automatic electronic controller.
- Tight-sealing, wedge-type door.
- Multi-insulation for maximum efficiency.

Shipped Ready to Operate
Model No. 16 Illustrated $1050.00



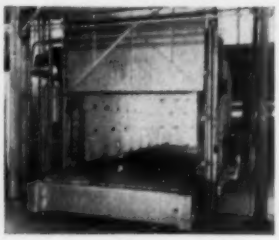
Also Special Models for Specific Requirements. Special KR-Supers to 3100 F.

K. H. HUPPERT CO.
Manufacturers of Electric Furnaces and Ovens For A Quarter Century
6844 Cottage Grove Ave., Chicago 37, Illinois

Request new catalog on furnaces, ovens, data, prices.

LIST NO. 194 ON INFO-COUPON PAGE 169

PACIFIC FURNACES ARE ENGINEERED FROM THE INSIDE OUT



The special wall holding anchor tiles developed and patented by Pacific have solved the problems of furnace wall failures due to unequal expansion and contraction of inner and outer wall surfaces. These wall holding anchor tiles save rebuilding time, costs and are GUARANTEED FOR FIVE YEARS.

Pacific ENGINEERS. . . . BUILDS . . . SERVICES all types of industrial heating equipment.

FOR COMPLETE INFORMATION ON OUR SERVICES —WRITE OR CALL

THE Pacific INDUSTRIAL FURNACE CO.

24680 Telegraph Road, Detroit 41, Michigan
Phone: Kenwood 7-4250

LIST NO. 173 ON INFO-COUPON PAGE 169

How to Cut Pot Costs:

Buy low-cost Eclipse pressed (not welded) steel pots . . . and replace them on a regular schedule.

1 Lower initial cost
2 Elimination of failures
3 Faster, more even heating
4 Quantity discounts earned on your total purchases in any 12 month period.

Guaranteed free from defects. Write:
Eclipse Fuel Engineering Company
Industrial Combustion Division
1127 Buchanan St., Rockford, Ill.

Eclipse PRESSED STEEL POTS

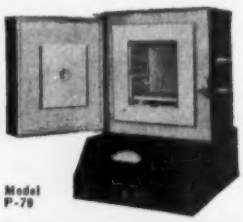
LIST NO. 176 ON INFO-COUPON PAGE 169

PRODUCED AND PRICED RIGHT FOR YOUR ELECTRIC FURNACE NEEDS

DYNA-TROL

MODEL NO.	FIRING CHAMBER (H.W.D.)	PRICE (300° to 2000°)	PRICE (400° to 2300°)
P46	4½"x4½"x8"	$90.00	$110.00
P79	9"x9"x9"	$285.00	$325.00
P918	9"x9"x18"	$460.00	$528.00
P414	14"x14"x14"	$525.00	$603.25
P124	12"x12"x24"	$715.00	$822.25
P818	18"x18"x18"	$775.00	$887.50
P136	18"x18"x36"	$1125.00	$1312.50

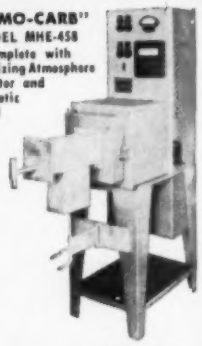
Automatic Controls Available on all Models



Model P-79

- Infinite zone temperature control
- Zone temperature indication by Pyrometer Selector Switch
- Automatic hold and cut-off instrument available
- Patented element holders
- Infinite variety of time-temperature curves obtainable
- Rugged construction

"ATMO-CARB"
MODEL MHE-458
Complete with Carburizing Atmosphere Generator and Automatic Control



$1325.00
Other Sizes and Arrangements Available

MANUFACTURING CO.
Chester 77, Pa.

LIST NO. 138 ON INFO-COUPON PAGE 169

MAN, METALS AND MODERN MAGIC

An ASM book of interest to both the expert and the student. The exciting story of the progress of metals. What metals mean to man.

$2.95

Order your copy from ASM Headquarters in Cleveland. Postage paid.

choose from the most complete line OF BASKETS, TRAYS, FIXTURES, RETORTS, CARBURIZING BOXES, POTS.



COR-WAL RETORT

Through serving commercial heat treaters and heat treating departments all over the U.S. for many years Stanwood has developed the most complete line of heat treating equipment. We can make fast delivery with maximum economy. If you require a special container, fixture or furnace part for which we do not have patterns our engineers can quickly develop and submit a design to meet your requirements. Send for catalog.
Sales Representatives in Principal Cities.



STANWOOD FIXTURE



HEAT TREATING EQUIPMENT

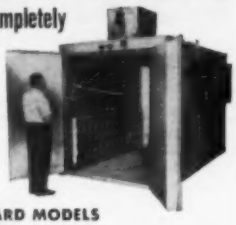
STANWOOD CORPORATION
4837 W. CORTLAND STREET • CHICAGO 39, ILL.

LIST NO. 12 ON INFO-COUPON PAGE 169

GRIEVE-HENDRY
WALK-IN OVENS

Shipped Completely "Set - Up"

Previously Tested and ready to operate.



6 STANDARD MODELS

No engineering charges

Latest convenience features and safety devices included. Design changes to suit requirements. Electric, gas or oil heated. Write for bulletin.

87 Standard Bench and Cabinet Models $110.50 and up

GRIEVE-HENDRY CO., INC.
1389 W. Carroll Ave.,
CHICAGO 7, ILL.

LIST NO. 27 ON INFO-COUPON PAGE 169

TAKING A BEATING



500 lb. loads, 12 hrs. a day, 5 days a week at 1600° F. temps. raise havoc with ordinary containers at BASSICK'S Bridgeport plant.

But since changing to WIRETEX BASKETS, life span is three times greater ... heat temps. extended ... corrosion ended ... loads distributed, handled better and faster. Free flow of quenching oil is assured; secondary handling eliminated. BASSICK engineers report increased production, improved quality control, greater savings.
If better heat treating is your problem ... Call Wiretex. Send for literature.

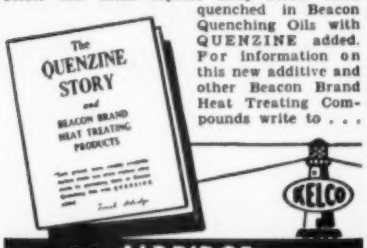
Specialists in Processing Carriers Since 1932.

Wiretex mfg. co., 5 Mason Street, Bridgeport 5, Conn.

LIST NO. 114 ON INFO-COUPON PAGE 169

FREE
the QUENZINE STORY

Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Quenching Oils with QUENZINE added. For information on this new additive and other Beacon Brand Heat Treating Compounds write to . . .



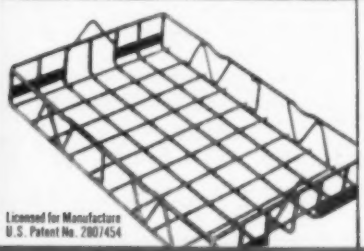
ALDRIDGE INDUSTRIAL OILS, Inc.
2401 W. 140th St., Cleveland 11, Ohio

LIST NO. 29 ON INFO-COUPON PAGE 169

ALLOY ENGINEERED RETORTS & BASKETS

Engineering answers and highest quality manufacturing ... developed by years of alloy specialization.





Licensed for Manufacture U.S. Patent No. 2801454

Designers ... Engineers ... Fabricators ... Call Alloy for quick service on all your heat treating requirements.

ALLOY ENGINEERING CO.

74 SHELDON ROAD
BEREA, OHIO

LIST NO. 184 ON INFO-COUPON PAGE 169

Regulate and control electric ovens and furnaces better, accurately, and efficiently, with SORGEL Saturable Reactors



Saturable Reactor with tap changing transformer

Any amount of A.C. power from 1 Kva to 3000 Kva, single phase or 3-phase, at any voltage, can be controlled, regulated, and varied in stepless increments, with SORGEL Saturable Reactors.

The control can be a small manually operated hand wheel that can be placed in any desired location, or it can be automatically controlled, regulated and varied by a thermostat or any other instrument or device.

SORGEL reactors are designed to meet your exact requirements. Let us know what your problems and requirements are, and we will submit our recommendations with complete information.

Write for Bulletin 658.

Also a complete line of dry-type transformers.

All standard and intermediate ratings, ¼ Kva to 10,000 Kva, 120 to 15,000 volts.

Sales Engineers in principal cities

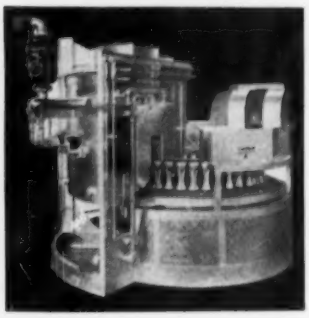
Consult the classified section of your telephone directory, under the heading "Transformers," or communicate with our factory.

SORGEL ELECTRIC CO., 834 W. National Ave., Milwaukee 4, Wis.

LIST NO. 195 ON INFO-COUPON PAGE 169

GOOD USED EQUIPMENT AT REAL SAVINGS TO YOU!

LIKE-NEW SELAS ROTARY-HEARTH HIGH-TEMPERATURE GRADIATION FURNACE!



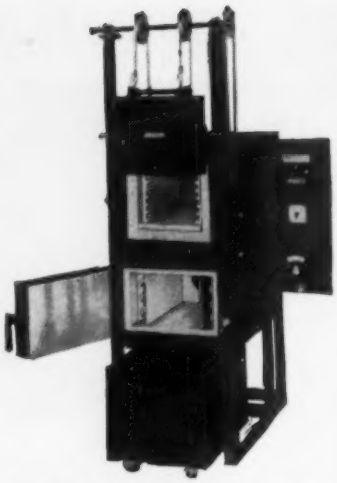
Hearth diameter, 7 ft.
Door opening, 8 in. wide by 22 in. high
Gas fired for 2400° F. Complete.
Also:

- Globar box furnaces, 12 in. wide by 18 in. long by 8 in. high
- Tempering box furnaces, 43 in. wide by 42 in. long by 30 in. high
- Carbonitriding furnaces, 24 in. wide by 36 in. long by 18 in. high
- Nitriding bell furnaces, 59 in. in diameter by 60 in. high
- Brazing roller hearth, 24 in. wide by 20 ft. long by 11 in. high
- Annealing roller hearth, 49 in. wide by 34 ft. long by 12 in. high

Wire or call for our complete list of used heat treating and plating equipment.

METAL TREATING EQUIPMENT EXCHANGE, INC.
9825 GREELEY ROAD
DETROIT 11, MICHIGAN

LIST NO. 142 ON INFO-COUPON PAGE 169



SAVE SPACE WITH A

SERIES 8055

COMBINATION MODEL

The Series 8055 is two electric heat treating furnaces (hardening 2000 and 2300° F., and drawing 800 and 1250° F.) in the floor space of one furnace. Each furnace is independently controlled permitting hardening and drawing operations to be performed at the same time. All models are delivered with separate controls for each furnace. The 8055 series is made in nine standard sizes . . . other models are made to your specifications. Furnaces operate on standard line voltage . . . no transformer necessary. A hardening and preheating combination is also available.

Write for a free catalog of the entire Lucifer line. Engineering advice is offered without obligation. Write, wire or call . . .

LUCIFER FURNACES, INC.
NESHAMINY 7, PENNA.
Phone: Diamond 3-0411

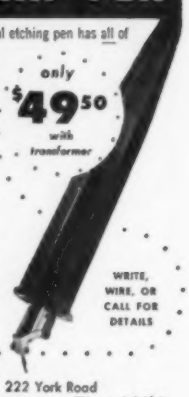
LIST NO. 122 ON INFO-COUPON PAGE 169

ARC ETCH ANY METAL OF ANY HARDNESS—*Quickly—Easily*
WITH THE
ACTOGRAP PEN

Only the ACTOGRAP metal etching pen has all of these features:

- Freedom from mechanical vibration
- Short, powerful, continuous arc—will etch hardest metals rapidly
- Does not heat up
- Light and small—can be used like a fountain pen
- Operates optionally on battery or conventional AC current
- Depth of etch can be regulated by an exclusive selection switch

only $49.50 with transformer



WRITE, WIRE, OR CALL FOR DETAILS

NEWAGE INDUSTRIES, INC.
222 York Road
TUrner 4-8494
Jenkintown, Pa.

LIST NO. 180 ON INFO-COUPON PAGE 169

Save with ULTRASONIC CLEANING EQUIPMENT by acoustica ASSOCIATES, INC

***PAID FOR ITSELF QUICKLY**

Otis engineers report that the Acoustica DR400 Ultrasonic cleaning unit "**paid for itself in the first six months operation... reduction of hand labor operations... resulted in a savings in the ultimate manufacturing costs.**"

Photographed at Otis Elevator Company, Electronic Division

The electronic chassis frames and sub-assemblies are immersed and cleaned of excess solder and solder flux in a fraction of the time previously required.

Write for "Building Blocks for Industry"

*LETTER ON FILE.



acoustica ASSOCIATES, INC. 26 Windsor Ave. • Mineola, N. Y. Pioneer 7-7800
11517 W. Jefferson Blvd. • Culver City, Calif.
Element 1-6250

LIST NO. 183 ON INFO-COUPON PAGE 169

Plan now to attend the 41st National Metal Congress and Exposition in Chicago, November 2 to 6.

Look ahead . . . you'll want to participate in this regular Metal Show that has the metal industry's stamp of approval . . . always successful for the exhibitor! Plan to take part . . . don't wait!

Floor plans and descriptive literature can be obtained by writing to ASM Headquarters in Cleveland.
7301 Euclid Avenue.

Need Help Designing That Aluminum Extrusion?

TEAM UP with JARL



THERE'S A WORLD OF DIFFERENCE

The *difference* starts the moment you meet the Jarl salesman. He's an engineer . . . well qualified to make on-the-spot recommendations in designs. Team up with Jarl and you'll get the right shapes made to most exacting design specifications. You'll be sure of close die control . . . quality safeguards every step . . . on-time deliveries. Send for our stock die catalog or send rough sketches for assistance with your design.

ANODIZING

JARL EXTRUSIONS, INC.
Dept. MP, Linden Ave. • East Rochester, N. Y.

LIST NO. 165 ON INFO-COUPON PAGE 169

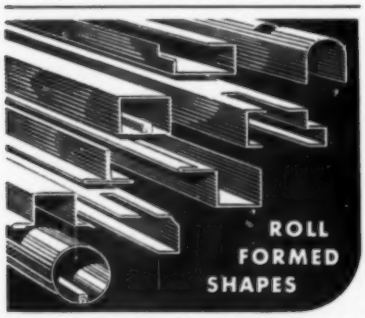


A NEW PRODUCT IS PLANNED

. . . and you have an idea that *one special* extruded aluminum shape can be used instead of *several standard* rolled sections of another metal, saving many manufacturing steps and money. The idea needs exploring . . . the opinion of experts. But, the budget for research of this type is slightly battered. The matter is no longer a problem, for G.E.I.'s highly skilled staff is eager and ready to discuss your idea with you, *at no obligation*, on one part or a million. G.E.I. engineers specialize in adapting extruded aluminum to new functional roles . . . and they can soon tell you whether your idea is fact or fancy.

GENERAL EXTRUSIONS, INC.
4040 LAKE PARK RD., YOUNGSTOWN, OHIO
Mill Representatives at St. Louis, Detroit, Memphis and Cincinnati
Consult your classified phone book under Aluminum Products.

LIST NO. 141 ON INFO-COUPON PAGE 169



Reduce your assembly problems and costs. Our shapes continuously formed, with high degree of accuracy, from ferrous or nonferrous metals. Write for Catalog No. 1053.

ROLL FORMED PRODUCTS CO.

MAIN OFFICE AND PLANT
3761 OAKWOOD AVE. • YOUNGSTOWN, OHIO

LIST NO. 101 ON INFO-COUPON PAGE 169

Sel-Rex®

PRECIOUS METALS FOR INDUSTRIAL PLATING

BRIGHT GOLD
Mirror-bright finish in any thickness directly from the bath. Patented

PUR-A-SALTS
Restores contaminated cyanide plating baths to full, trouble-free operation. Patented

SILVREX BRIGHT SILVER
Crystal-clear solution that produces mirror-bright deposits. Patented

SILVER SOL-U-SALT
Non-dusting—safest and easiest to use.

BRIGHT RHODIUM
Brilliant, fine-grained non-tarnishing deposits.

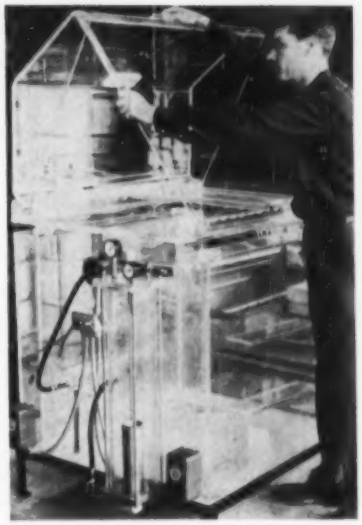
RHODEX
Only rhodium electroplating process that yields extra heavy compressively stressed deposits. Patent Pending

ACID GOLD PLATING PROCESS
Developed specifically for plating printed circuits. Mildly acid so that neither the laminate nor the adhesive at the inter-face of printed circuit boards are affected during the plating process.

Complete installation and servicing on all precious metals processes.

SEL-REX CORPORATION
Dept. BB, Nutley 10, New Jersey

LIST NO. 108 ON INFO-COUPON PAGE 169



Top Uniform Accuracy Over-All Visibility at Lower Cost!

★ **SALT FOG**
★ **CORRODKOTE**
★ **HUMIDITY TESTS**

Get the best from every test with **G.S. Corrosion Test Cabinets**

Designed to meet A.S.T.M. and Gov't Specifications. Many new, exclusive, features. All-welded H-T Lucite, lined Steel or lined Stainless—sizes, types to suit. Send for details, prices.

The G. S. Equipment Co.
15585 Brookpark Rd. Cleveland, Ohio
Phone: CL 2-4770

LIST NO. 196 ON INFO-COUPON PAGE 169



- **CLAMPS, JAWS & BASE PLATE ARE ELIMINATED**
- **NO CONVERSIONS OR CALCULATIONS**
- **TEST ANY SIZE, SHAPE OR TYPE METAL**
- **NO SKILL REQUIRED**
- **SCALE READINGS IN ROCKWELL & BRINELL**
- **ACCURACY GUARANTEED**

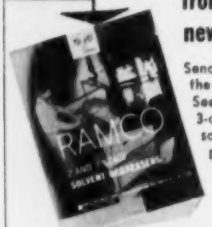
Many thousands used by industry and government. Write, wire or call for additional details and prices.

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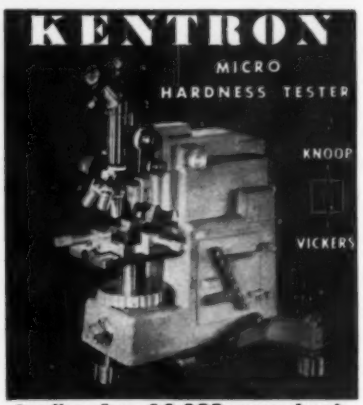
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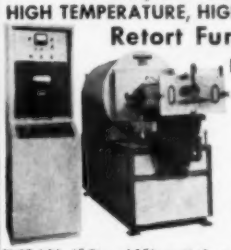


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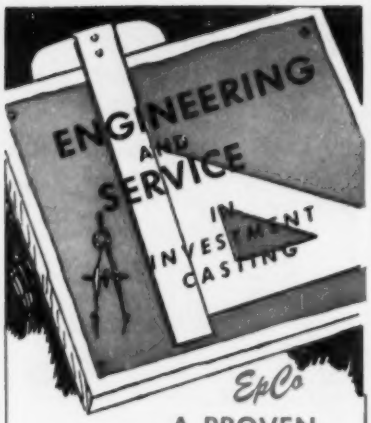
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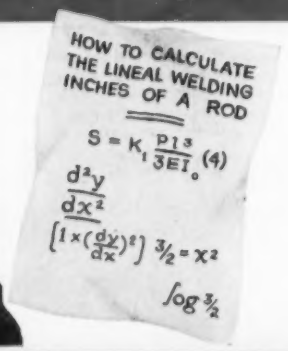
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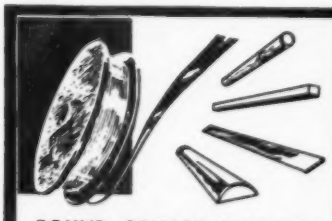
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CO_2 Welding . . .

(*Continued from p.* 114)

Because of this and because corrosion resistance is lower (both may be due to carbon pickup), CO_2 shielding is not recommended for stainless steel welding at this time.

There is no doubt that CO_2 produces sounder welds, in applications for which it is suited, than argon shielding. The reason for this is not understood. The best guess is that the violently agitating weld puddle releases gas bubbles formed inside the molten pool.

Welding Wire Important

Since flux is not used in the CO_2 process, it is essential to match the wire to the material. For several years wires for CO_2 welding were primarily designed for use with argon. This was no more than a stopgap arrangement and further tests established more suitable wire chemistry: Larger additions of silicon (0.45 to 0.60%) improved the soundness of the weld metal, gave better arc stability and reduced spatter.

Addition of aluminum deoxidizer has also been helpful in reducing porosity in the weld metal. Aluminum additions of 0.55 to 0.90% in the form of aluminized coating improved the weld quality. Unfortunately, however, the aluminum would flake off as it passed through the wire feed rolls and contact tips. The problem was solved by alloying aluminum in the electrode wire.

A. O. Smith Corp. pioneered in the use of combinations of aluminum, silicon and manganese in core wire for the CO_2 process.

Page Steel & Wire Div., American Chain and Cable Co., Monesson, Pa., were also early workers in developing special CO_2 wire. Page's Vincent Godfrey gives this account of an early experiment: "One of our customers was having difficulty welding 1035 steel. We messed around with a high-tensile steel wire, added some silicon, and the more we added the better it got – up to 0.90 silicon, that is. This wire is used to weld steels containing as much as 0.50% carbon."

Flat Wire Electrode – According to Godfrey, initial welds made with a flat wire show that with the flat side facing the direction of travel it is possible to obtain a flat bead and shallow penetration to compensate for inconsistencies in fit-up. When this same wire is run with the flat side parallel to the direction of travel, this manufacturer claims that deeper penetration is obtained than with a round cross-section wire.

(*Continued on p.* 172)

Fig. 10 – This Steel Casting Is Being Built Up With the Aid of a CO_2 Semi-Automatic Welding Gun. (Courtesy A. O. Smith Corp.)



Braze and Anneal at operating temperatures from 400°F to 2150°F



Model 88 Bell Retort Furnace.

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Removable bell retorts containing work pieces are heated within a cylindrical furnace, as a low dew-point, dry hydrogen or cracked ammonia atmosphere is maintained.

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CO_2 Welding . . .

Corrugated Wire Electrode – Engineers at Fisher Body are experimenting with a corrugated (0.045-in.) wire electrode. It produces a wide weld on thin-gage material to compensate for limited trim tolerances. As Fisher's Thomas Shearer explains, "Corrugating is accomplished with gear-shaped wire feed drive rolls. Wire enters the rolls straight and emerges corrugated. As the wire melts, the deposit oscillates from side to side."

Size – Popular welding wire sizes range between 0.030 and ⅛ in. The most popular wire diameter appears to be 1/16 in. for all-around welding usage. Wires over 0.045 in. in diameter tend to deposit the bead so rapidly that contour control becomes difficult.

High Current Density – Due to the small size of electrodes the process establishes very high current densities, exceeding 200,000 amp. per sq.in. In submerged arc welding, for example, densities of about 30,000 amp. per sq.in. are common. The high current density of the small-diameter wire results in a spray-type transfer.

Modifications of CO_2 Process

Several novel approaches exist. Quasi-Arc, Ltd. of England is using a CO_2 shield around a coated spirally-coiled wire electrode. National Cylinder Gas Div., Chemetron Corp., uses a granular flux-cored bare wire electrode, and this is shielded with CO_2 gas. Linde Div., Union Carbide Corp., employs a bare wire electrode surrounded by a magnetized granular flux which is shielded in a CO_2 gas atmosphere.

Quasi-Arc Process – The Quasi-Arc process has a simplified electrode coating. The hydrogen content is lower than that normally existing in a similar type stick electrode coating. Specimens are claimed to have all the quantities of low-hydrogen weld metal. The makers say that the electrode offers the same high tolerance to sulphur in steel that is offered by conventional low-hydrogen electrodes.

In the National Cylinder Gas process a granular flux is contained within a steel electrode casing. In this way the amount of flux fed to the molten pool is accurately controlled. In addition to handling low to medium-carbon steels, it is claimed that such materials as T-1 and A-202 steels are also welded. Some scale and rust can be tolerated. This flux-cored electrode process is shown in Fig. 6.

The Linde process (Fig. 7) works in this manner: The solid wire electrode is fed out of the welding gun surrounded by a coating of granular flux and shielded in a CO_2 atmosphere. At the torch nozzle, the magnetic field surrounding the energized welding wire magnetizes and attracts flux to the wire. Two advantages of this process are immediately evident: First, since it is not affected by gravity, it will deposit weld beads out-of-position, and second the arc is constantly visible.

Welding Applications

Up to this time the CO_2 process has been limited to welding various grades of carbon steel – rimmed, semikilled and killed steels. Weld-

(*Continued on p. 176*)



TYPE SVU, Size 9, Automatic Flash Welding Machine has clamping force of 40 tons, upsetting force of 27 tons. Maximum welding section 25 sq. in.

Known abroad for their precision performance, ASEASVETS Type SVU Automatic Flash Welding Machines are now available in the United States.

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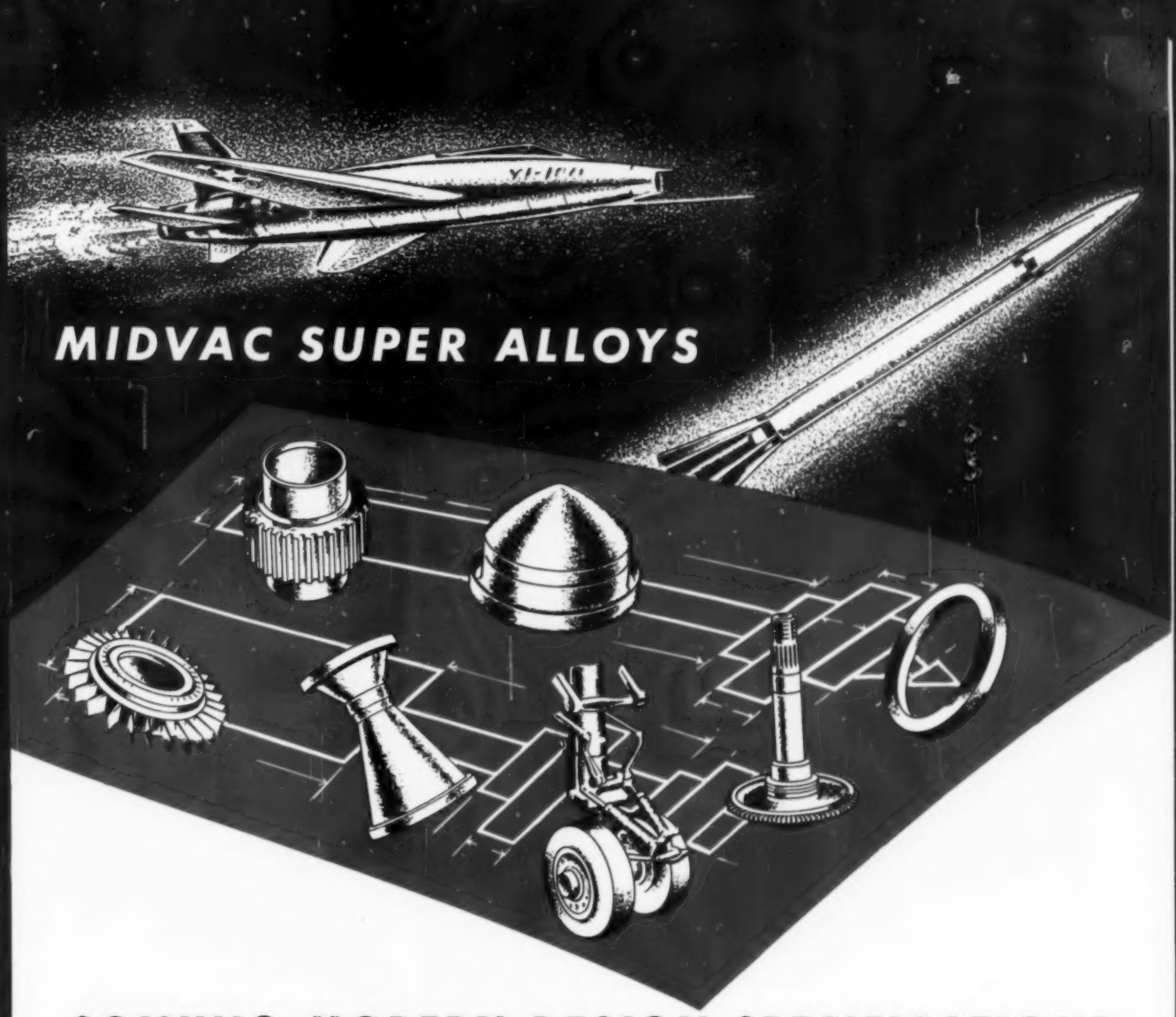
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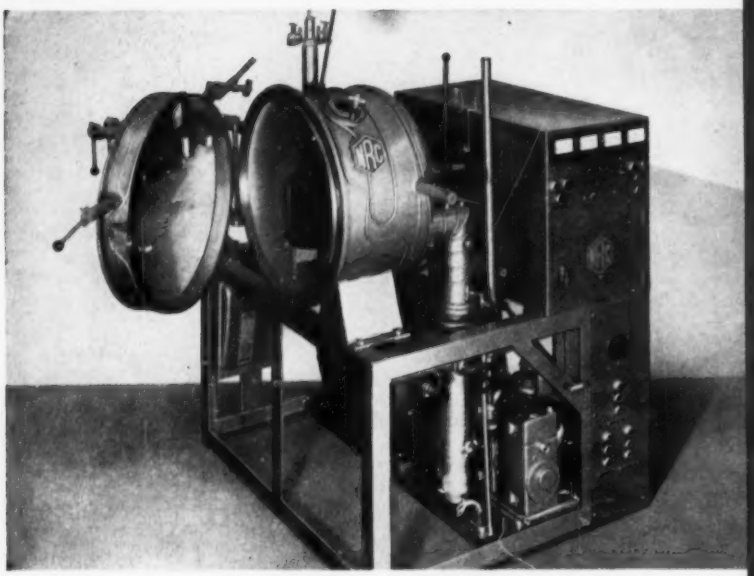
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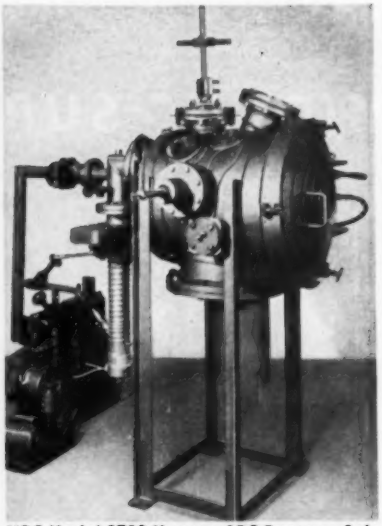
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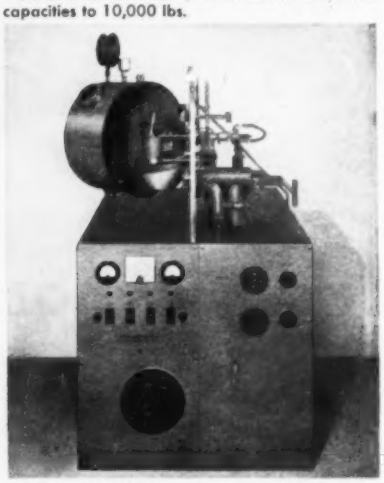
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*Flexals can be either soluble or insoluble in water for solvents, depending upon need.

CO_2 Welding . . .

ing of stainless is out of the picture at the moment.* There is little hope of applying the process to joining aluminum, magnesium, titanium, vanadium, tungsten and zirconium, since it has been impossible to prevent oxidation and high temperature reactions in the weld metal.

The question of fit-up in CO_2 welding is critical in many applications. J. J. Chyle, director of welding research, A. O. Smith Corp., put it this way: "The case of fit-up is a critical factor for all automatic welding processes, and CO_2 welding is no exception. . . In light sections, because of the greater penetration of the CO_2 welding process, special attention must be given to backing up of the light sections, and use of the proper welding procedure to obtain a high-quality weld metal deposit.

As the speed of welding increases with the CO_2 welding process, greater emphasis must be directed toward establishing closer tolerances in welding fixtures by our design engineers."

*Some investigations being made in this country and abroad indicate that for some applications of stainless welding the CO_2 process is feasible.

Light-Gage Sheet Steel – The CO_2 process is used extensively to join sheets of mild and carbon steels. High-speed lap welds head the list. Here, good fit-up is usually essential. In automatic work a stable jig and fixture and an effective tracking mechanism are also important. With the aid of the new reactor, very high-speed lap welds can be obtained welding vertically down. Butt welds require careful preparation, especially if the application calls for complete penetration. In the latter instance, a steel or refractory chill is necessary. Circular welds require good fit-up and tracking should be accurate. The best girth welds are made with the welding head trailing the vertical centerline. Before making edge welds, the apparatus must be modified to maintain the gas envelope in the weld zone.

According to Parish's Holzman, his operators are obtaining speeds up to 120 in. per min. in welding 0.090-in. automobile frame side rails (Fig. 8). "On ideal setups for other products, we get up to 240 in. per min."

Heavy-Gage Materials – Materials ¼ to 1½ in. thick can be fillet and butt welded very effectively. Here, the deep penetrating quality of the process is an advantage. This quality is apparent in the sectioned fillet weld shown in Fig. 9. Also note the smoothness and lack of spatter. For welding heavy plate the CO_2 process does not appear to be as useful or as economical as the submerged arc welding process in most applications.

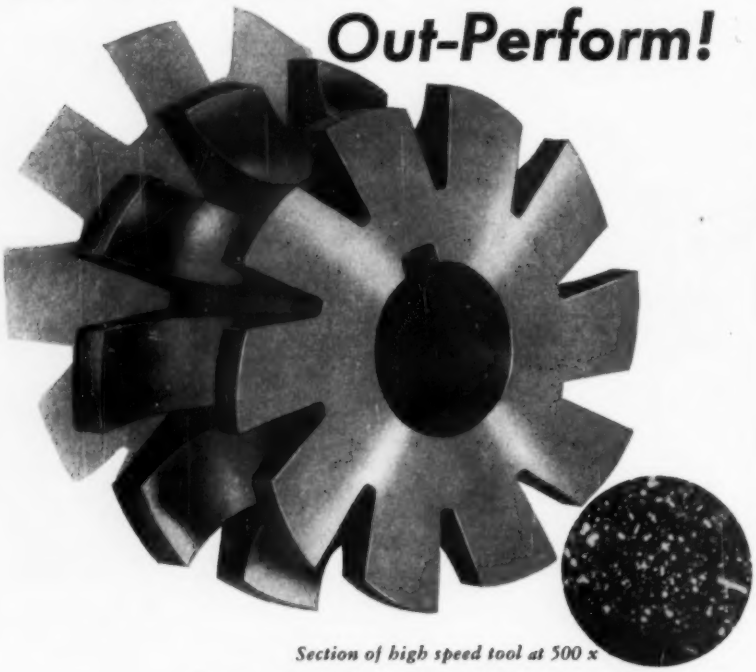
Foundry castings – The build-up of large steel castings has always been a time-consuming operation. It is claimed that the CO_2 process used to build up the steel castings shown in Fig. 10 provided a 477% increase in deposition rate over hand-held "stick" electrodes.

Economics of Process

In gas shielded welding, carbon dioxide gas, supplied in cylinders, is about 1/9 the cost of argon. Therefore it is not hard to understand why the CO_2 process is an attractive proposition. On light-gage material the carbon dioxide welding process is, in many applications, much more economical than any other process. It is especially more economical than manual arc welding because much higher deposition rates are obtained using CO_2.

(*Continued on p.* 178)

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Section of high speed tool at 500 x

The truly neutral Sentry Diamond Block atmosphere permits ample soaking of all high speed or high carbon high chrome production tools to assure uniform hardness throughout.

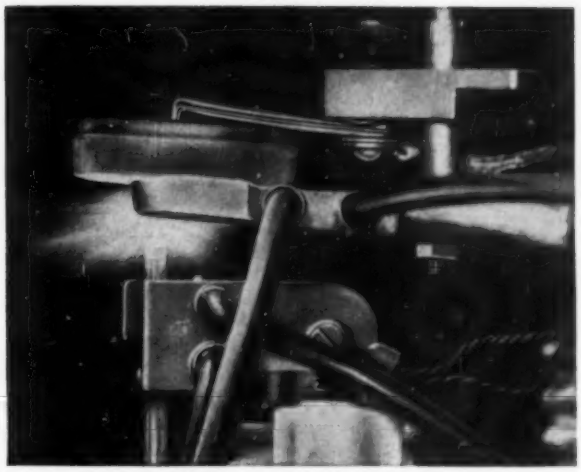
Original sharp edges are retained through the hardening cycle. There is no scale and no decarburization. As a result, tools hardened the Sentry way give maximum service under difficult working conditions.



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Pour samples are sent immediately to the laboratory from furnace platforms through a system of pneumatic tubes. The sample is prepared in the laboratory and excited using pre-arranged source conditions. "National" graphite rods are used as a counter-electrode in this application.

Results — obtained quickly and economically by direct reading spectroscopy — permit Bridgeport Brass Company to maintain elements and impurities within the limit of metallurgical standards.

NATIONAL GRAPHITE helps measure these elements and impurities

"National" graphite rods—the purest graphite obtainable — are being used for analysis of 95 to 100 per cent of all castings produced from induction, arc and continuous casting furnaces, at Bridgeport Brass Company.

Be sure to specify "National" for your spectroscopic work. This brand of graphite in electrode or powder form, is accompanied by a "statement of purity" describing the trace-elements present. You are thus forewarned against errors arising from unexpected spectral lines.

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STRAITS TIN REPORT

New developments in the production, marketing and uses of tin

MALAYAN TIN BUREAU

★

Five times cheaper than stainless steel. That's what the British dairy industry reports about seamless tinned steel milk cans. It finds that a heavy tin coating gives a good adherent finish, provides excellent corrosion resistance, is completely nontoxic, and does not in any way affect the flavor or the nutritive value of the milk.

★

The increasingly important role of tin in this age of the jet and missile is again confirmed. A tin-zinc alloy is being used to plate jet aircraft hydraulic brake parts and thus prevent corrosion. The alloy is 75% tin and 25% zinc.

★

Another new product is available in the popular aerosol cans. It is Freon, an odorless, colorless gas normally used as a refrigerating agent. The aerosol Freon bomb will double as your personal, portable tire pump and fire extinguisher. It can be used to inflate the average tire with 22 pounds of pressure in just 6 seconds. It kills fires by depriving the flames of oxygen and lowering the surrounding temperature.



Ask us to send you TIN NEWS, a monthly letter. It will keep you posted on tin supply, prices, new uses and applications.

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CO_2 Welding . . .

Bulk Storage – Fabricators are learning more about the economics of handling CO_2. Parish Pressed Steel uses large amounts of welding grade carbon dioxide gas. According to Mr. Holzman, the division employs a 10-ton and a 12-ton liquid carbon dioxide receiver. These bulk storage units feed CO_2 gas to several welding stations. A manifold connecting the two receivers feeds the mains at tank pressure of 275 psi. Gas is piped through the plant at this pressure and is reduced to 20 psi. by means of a regulator at each branch line. Then the gas passes through flow meters and on into the welding nozzle. Says Holzman: "The advantages of this central storage system are not only safety and convenience, but more importantly, perhaps, the elimination of downtime due to frequent replacement of cylinders."

Ryan Aeronautical Co. estimates that replacement of a one-cylinder system costs $1.50 for labor alone – without considering lost production time. To avoid contamination the single cylinder is not completely emptied – another loss. Probably the major benefit of bulk use is the saving provided by bulk purchase.

Welding Fumes – The process appears to have been given a clear bill of health by the industrial safety departments of many companies. High concentrations of carbon monoxide exist in a very narrow range of 4 to 6 in. of the arc. Beyond this point the percentage of carbon monoxide in the atmosphere falls off rapidly. If standard welding ventilation requirements are followed*, the safety aspects are about the same as when welding manually or automatically with coated electrodes. Ventilation is required in confined spaces not only for CO_2 but for all welding processes.

*See Paragraphs 8.3 and 8.4, "Safety in Welding and Cutting," Z49.1, prepared by an American Standard Assoc. committee under American Welding Society sponsorship, Published by the A.W.S., 33 West 39th St., New York 17, N.Y., 1958, $2.00.

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Write For Bulletin 64-H.

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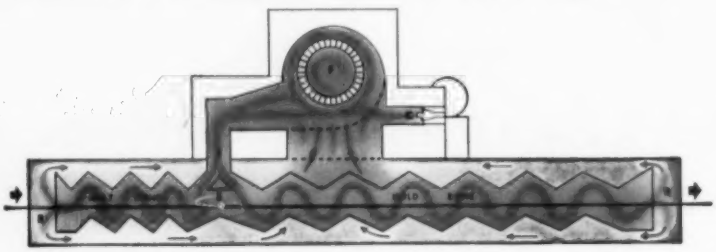


Industrial's "Circ-Air" tempering furnace is the most efficient heating machine ever designed.

The turbulent recirculation of hot gases through and around the work insures maximum and uniform heat transfer. Proper channeling of the hot gases to the work prevents wasteful dissipation of heat; and puts heat where it is needed — on the work.

A "Circ-Air" processing 2000 lbs. per hour at 1300° F., holding ±5° F., forces 14,500 C. F. M. of hot gases through the work. "Circ-Air" heating is recirculation at its best.

The continuous "Circ-Air" is suitable for heating steel, brass, aluminum and cast iron at temperatures up to 1450° F.



WHY THE CIRC-AIR IS THE BEST TEMPERING FURNACE!

The work is carried on a continuous conveyor. Loading can vary; ¼" bolts are densely loaded up to 3" deep. Less dense loading may be 20" deep. A 3' x 21' "Circ-Air" tempers over 2000 lbs. per hour.

Hot gases from the combustion chamber "C" and recirculated gases returning from the work chamber mix in the fan area "F." Entering the heating area through "T" at control temperature, balanced heat is directed to the charge and discharge ends, and is returned to the mixing chamber. The continuous V construction of the metal liner forces the hot gases up and down through the load at high velocity. The hot gases in the heating zone flow counter to the work. Heat transfer is rapid. Equilibrium is reached at point "E", and ±5° F. is held the length of the holding zone. Heating is without temperature head.

"Circ-Air" furnaces have been built in widths up to 108 inches, in lengths up to 165 feet, for temperatures from 250 to 1450° F., and capacities from 200 to 16,000 lbs. per hour. *Send for Bulletin 13-A*

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PIONEERS AND STILL LEADERS IN RECIRCULATION

Stress-Corrosion Cracking

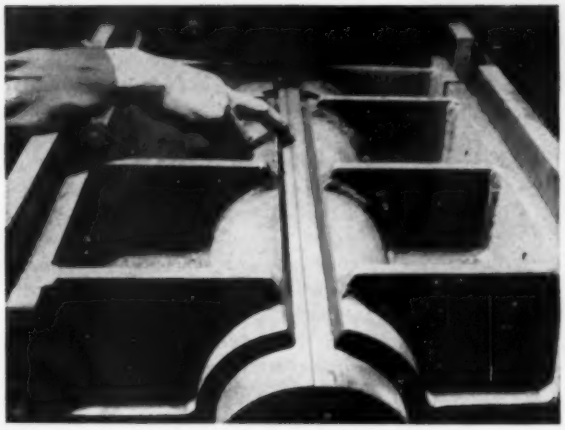
Digest of "Chloride Stress-Corrosion Cracking of Austenitic Stainless Steel — Effect of Temperature and pH", by L. R. Scharfstein and W. F. Brindley. Paper presented at national meeting of National Assoc. of Corrosion Engineers, March 1958.

FIFTEEN YEARS AGO, reported incidents of stress-corrosion cracking of austenitic stainless steels were rare. The increased use of stainless steels during the past few years has resulted in a great rise in such reports. The major offenders have been aqueous chlorides. The tendency of stressed austenitic stainless steel to crack when exposed to chloride-bearing water at elevated temperatures is well known. However, only a few cases of chloride stress-corrosion cracking in dilute solutions at temperatures below the boiling point of water have been reported. This fact alone indicates that a reduction in temperature must lead to a reduction in the susceptibility of austenitic stainless steel to this type of attack.

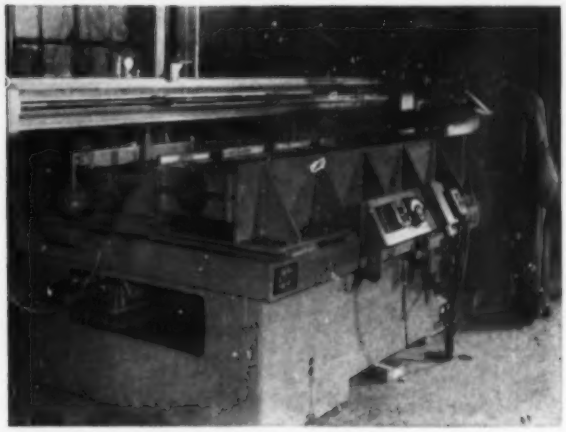
A statistically designed test program was carried out to determine the susceptibility of austenitic stainless steels to stress-corrosion cracking in dilute sodium chloride solutions between the temperatures of 165 and 200° F. and with the pH varying from 6 to 12. U-bend specimens were fabricated for testing from as-received A.I.S.I. Types 304, 347, and a 1200° F. sensitized 304 stainless steel. A 34-liter thermostated pyrex container allowed simultaneous testing of 30 specimens. Initial experiments indicated that cracking was usually initiated in less than 48 hr. so this was adopted as the time of a test.

Gross crack analysis was made using a fluorescent penetrant and a binocular microscope, and final crack analysis was based on microscopic examination.

A "safe" population sample size was required. It was observed that one crack in only ten specimens could actually mean 460 cracked specimens if 1000 were tested with a 95% confidence. On the other hand, if no cracks were observed in ten specimens, as many as 330 cracked specimens might be the re-



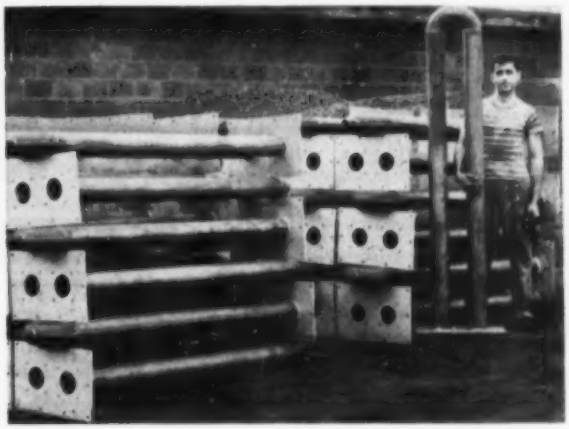
Radiant tube is jigged for automatic welding . . . worker checks edge alignment before starting welding cycle. Notice absence of chamfering — full penetration of the Nickel alloy is now obtained without such joint preparation.



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Incoloy radiant tubes, other furnace parts, are operated in temperatures up to 1850°F. Inconel tubes and parts now work in temperatures up to 2200°F, show excellent resistance to most furnace atmospheres. Both alloys have ample strength for practical heat-treating equipment design, are readily welded and formed.

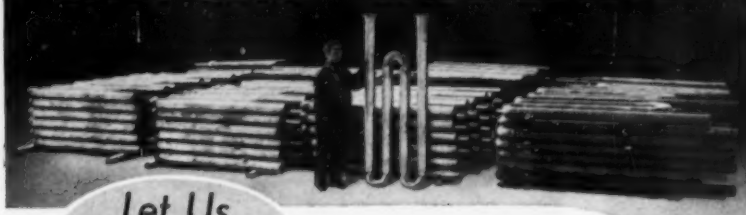
For more about these fabricated radiant tubes, write Pressed Steel Company, Wilkes-Barre, Pa. For information on Inconel and Incoloy alloys, contact your Inco Nickel Alloy distributor. He's listed under "Nickel" in the "Yellow Pages."

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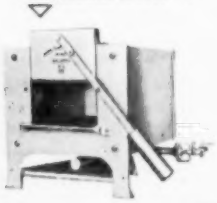
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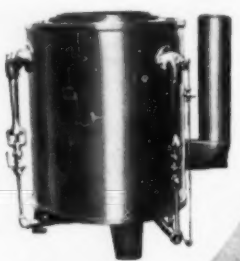
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Stress-Corrosion . . .

sult if 1000 were tested. A sample size of ten was chosen and if cracks were found, supplementary tests were run.

Results in neutral solutions indicate that stressed austenitic stainless steels are susceptible to chloride stress-corrosion cracking at temperatures as low as 165 to 200° F. with as little as 5 ppm. chloride in the water. Sentitized 304 is less resistant to attack than Types 304 and 347. Tested specimens had discolored spots on the tension side of the U-bend and all cracks were associated with rust spots. Specimen pitting increases with chloride ion content in neutral solutions and is a maximum at 185° F. Dissolved oxygen in the solution slightly increases the rate of attack. Cracking in the sensitized specimens is predominantly intergranular, whereas it is transgranular in the unsensitized specimens.

Results in basic solutions verify that an increase in pH reduces pitting by aqueous chloride and that phosphate ion additions will inhibit stress-corrosion cracking even in solutions containing 550 ppm. chloride. However, if insufficient alkaline phosphate is present, large pits will form in sensitized 304. Equimolar concentrations of phosphate and chloride results in all specimens being free of pits and/or cracks.

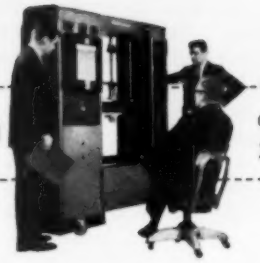
D. L. McElroy

Notch Toughness of Welded T-1 Steel

Digest of "Studies of the Weld Heat-Affected Zone of T-1 Steel", by E. F. Nippes, W. F. Savage and R. J. Allio, *Welding Research Supplement*, Vol. 36, December 1957, p. 531-540s.

A number of new constructional steels combine high yield strength, good weldability and good low-temperature toughness. One of these materials, a low-alloy steel designated T-1, has satisfactory impact strength in the as-welded state. The favorable mechanical properties of this material are contingent upon the presence of low-carbon martensite. It appears reasonable, therefore, that preheating or high energy

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Twinning in Face-centered Cubic Metal

Recent studies of the deformation characteristics of copper single crystals at 4.2°K and 77.3°K were made on the Instron Universal Tester equipped for low temperature testing.

Special x-ray techniques were used to examine the tested samples . . . one of the results: *mechanical twinning in face-centered cubic metal.*

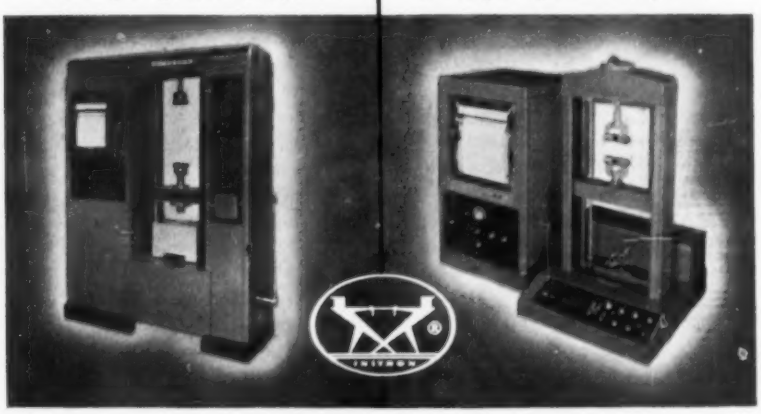
This heretofore unproven fact is verified in a 10-page, illustrated article on the testing of copper single crystals which is now available to you. Write for bulletin M-2 . . . it is one of many technical articles covering all fields of testing now ready for you in reprint form.



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Notch Toughness . . .

inputs would be detrimental to the notch toughness of this material. Since pressure-vessel steels, such as T-1, are often preheated prior to welding, and since submerged-arc welding is frequently used, properties of the heat affected zone of T-1 were investigated.

The material used was ½-in. T-1 plate of nominal chemical composition and mechanical properties. Existing data were supplemented by investigating the thermal cycles resulting from high energy inputs and high travel speeds. Times and temperatures were measured in the metal adjacent to a butt joint weld from which values of F (s, d) were calculated. F (s, d) is a function of the distance, d, from the weld center line at time, s, after the arc passes.

The transformation of T-1 steel upon continuous cooling was investigated by thermal evolution techniques and by high-speed dilatometry. The thermal evolution technique made use of ⅛ in. × ⅛ in. × 0.05 in. specimens. Temperatures were recorded with a high-speed oscillograph. Dilation was measured by means of an optical grating extensometer. By austenitizing a large number of specimens and observing their thermal and dilation behavior upon cooling, the continuous cooling transformation diagram was determined.

Utilizing thermal-cycle data, test specimens were prepared having the precise microstructure existing at any point in a weld heat affected zone of ½-in. plate under a variety of welding conditions. The effect in ½-in. plate of weld thermal cycles at 47,000 joules per in. energy input, peak temperatures of 1600, 2200 and 2400° F., and initial plate temperatures of 200, 300 and 500° F. were studied. Specimens for heat treatment were prepared from ½-in. plate. The signal from a thermocouple welded to the sample surface was balanced against a signal previously designed to reproduce the desired thermal cycle. Standard Charpy V-notch specimens were prepared from the heat treated blanks, the notch being oriented normal to the plate surface. A minimum aging time of 21 days at room temperature was allowed before fracturing.

(*Continued on p.* 184)

Notch Toughness . . .

Previous work shows that the impact properties of T-1 steel are not impaired by welding with an energy input of 47,000 joules per in. and an initial plate temperature of 72° F. Impact data indicate a marked decrease in toughness with either increasing initial plate temperature or increasing energy input. In one instance, a T-1 plate, experiencing a thermal cycle with a 2400° F. peak temperature and a 500° F. preheat, raised the ductility-transition temperature from −138 to +26° F. with a similar effect on the fracture-transition temperature. Increased energy input had an analogous effect on toughness.

Metallographic examination of specimens subjected to 2200° F. peak temperatures shows grain refinement at low preheat temperatures but grain growth at the higher preheat temperatures. An almost completely martensitic structure is associated with the specimens subjected to 2200° F. peak temperatures and no preheat, while increasing preheat temperatures greatly increased the amount of ferrite and carbide precipitation.

The poor impact behavior of specimens welded under conditions of high plate preheat or high energy input can be explained by the microstructure. The retention of toughness associated with no preheat and low energy input has been attributed to the outstanding properties of low-carbon martensite. Should this constituent be replaced by a structure consisting of an aggregate of ferrite and high-carbon martensite, a notably brittle constituent, the toughness of the material would be destroyed.

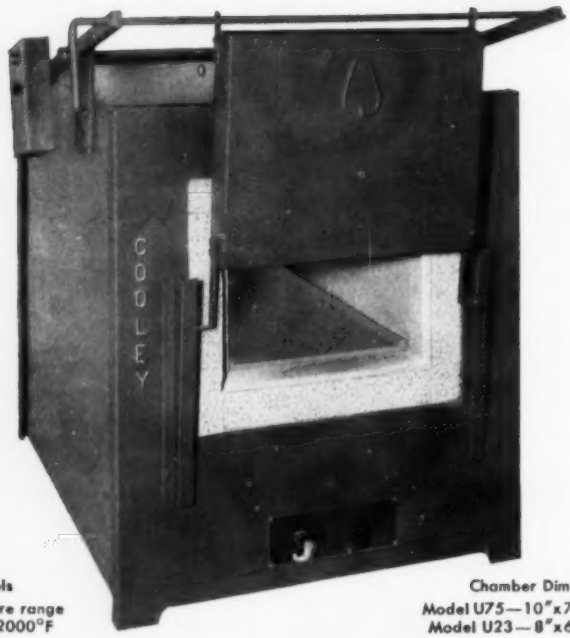
A single parameter which would permit a prediction of impact performance was believed advisable. Since microstructure, cooling rate, initial plate temperature and energy input are closely interrelated, it was considered that the impact performance could be equated to the cooling rate. Continuous cooling data suggested the cooling rate at 900° F. would be the most sensitive to microstructure and thus toughness. Using the ability to absorb at least 10 ft-lb. of energy at −50° F. as a specification of nonbrittle failure, a minimum cooling rate of 6.5° F. per sec. is required. Since notch toughness is a function of microstructure, it has been possible to define the welding conditions that produce cooling rates of 6.5° F. per sec. in plate thicknesses other than ½ in. Welding with submerged-arc techniques reduces cooling rates as compared to manual-arc welding methods and requires a reduction in either preheat or energy input to produce the same microstructure.

There are several limitations to the use of these data in predicting actual service performance. Although a cooling rate of 6.5° F. per sec. will produce similar microstructures in any size plate, brittle failure will be more probable in thick plate because of its greater notch restraint. Furthermore, a low notch toughness in the heat affected zone does not assure that failure will originate or propagate in this zone in a welded structure. The residual stress pattern after welding must also be taken into consideration when predicting actual service performance.

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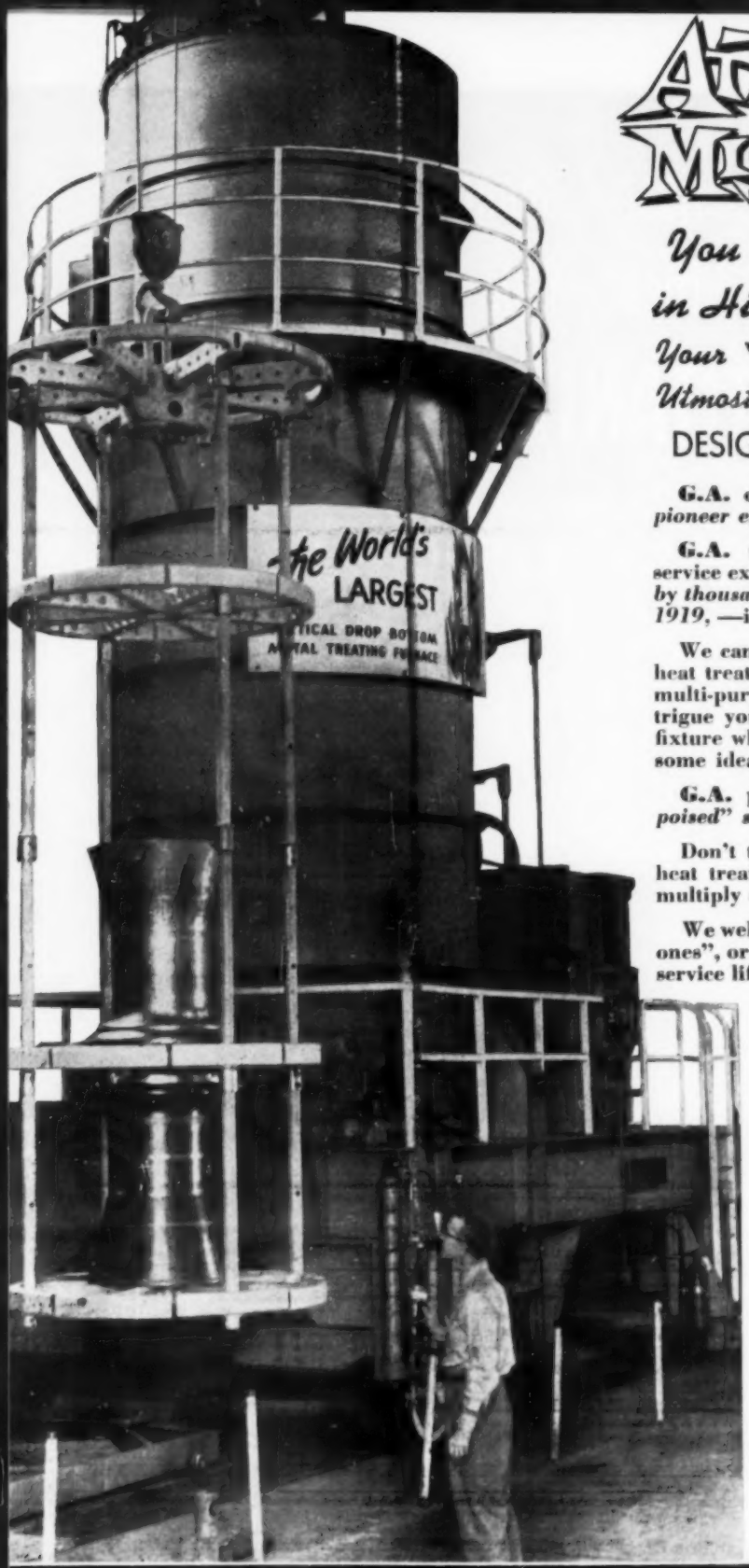
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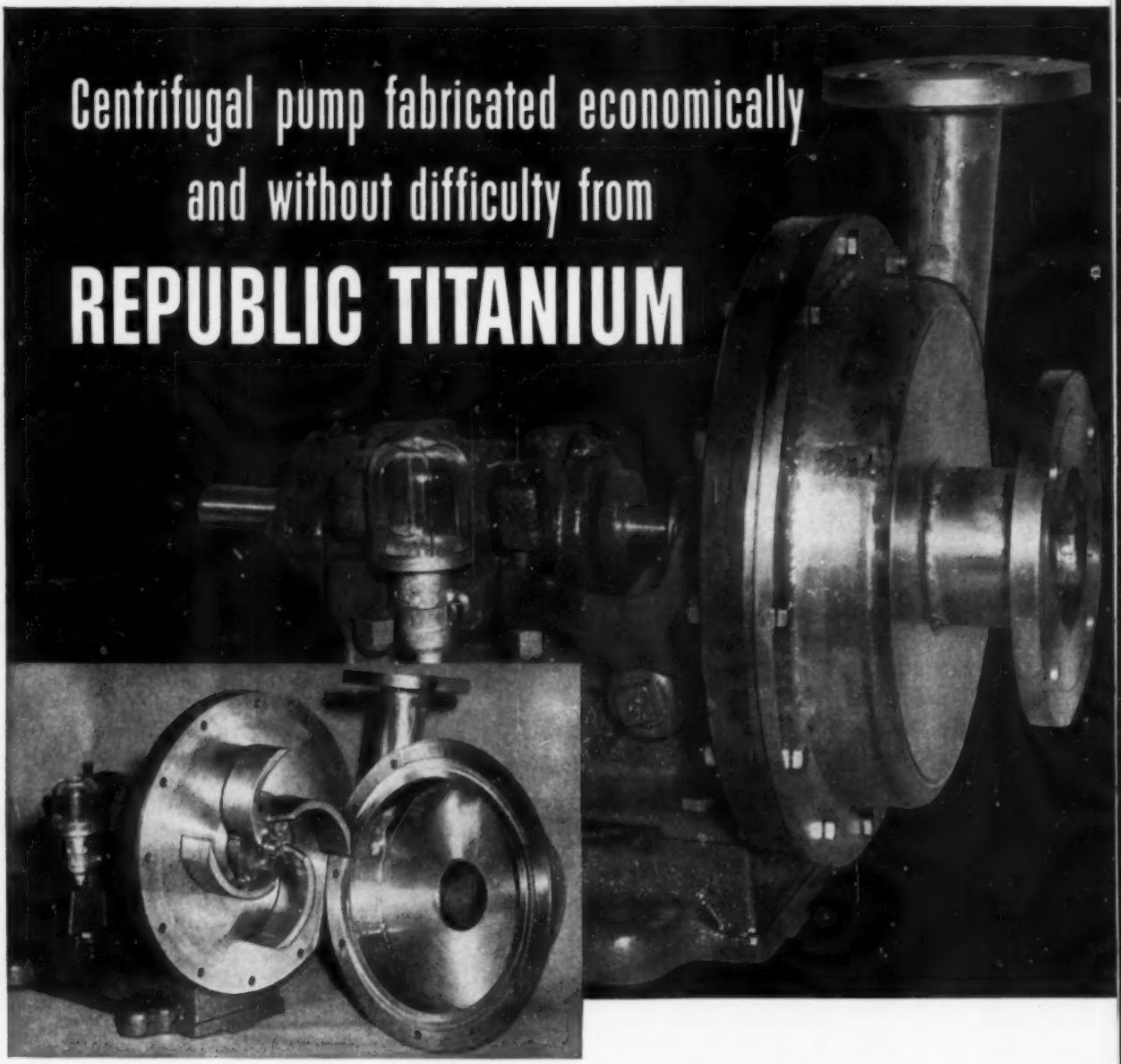
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A pioneer in heat treating missile bodies and rocket motor housings employs fixture illustrated to support a load of 10,000 lbs. at 1500° F., and over 3,000 lbs. at 1900° F. The fixture is 5 ft. in diameter and 16 ft. high. It is quenched in salt at approximately 400° F. G.A. proprietary "Tublarform" scientifically stressed components designed toward optimum distribution of thermal stresses is employed.

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Centrifugal pump fabricated economically and without difficulty from REPUBLIC TITANIUM



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Performance ratings are essentially similar to those obtained for cast iron or corrosion-resistant alloys. Fewer pump sizes are required because the flat characteristics of Mission's impeller design provide a wide operating range and sustained efficiencies.

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Does this application of Republic Titanium spark an idea for your product that needs to be strong, lightweight, and corrosion-resistant? Republic Metallurgists and Machining Specialists will help you apply titanium's advantages now.

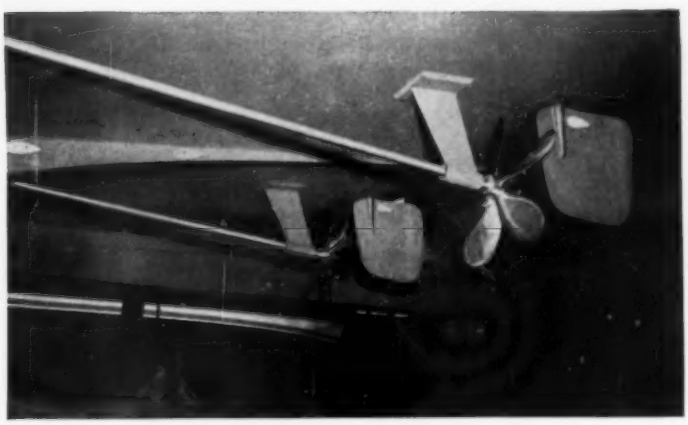
Republic produces commercially pure titanium and titanium alloys in ingots, billets, hot rolled and cold finished bars, plates, sheets, and strip. Mail the coupon for more information on these titanium forms, or for metallurgical and machining assistance.



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IMPROVED PRODUCT PERFORMANCE is reported by Roamer Steel Boats, Division of Chris-Craft Corporation, since switching to Republic Cold Finished Stainless Steel Bars. Vibration, a mechanical problem caused by out-of-true drive shafts, has been reduced to a minimum by Roamer through standardization of stainless shafts for their line of pleasure cruisers. The shafts are machined from uniformly straight Republic Cold Finished Stainless Steel Bars, Type 304. The bars meet Roamer's strict, maximum tolerance requirement of .006" runout in 72" of shafting. Stainless steel shafts also provide high strength and outstanding corrosion resistance. Republic specialists will help you use Cold Finished Stainless Steel Bars to best advantage. Mail coupon for more information.

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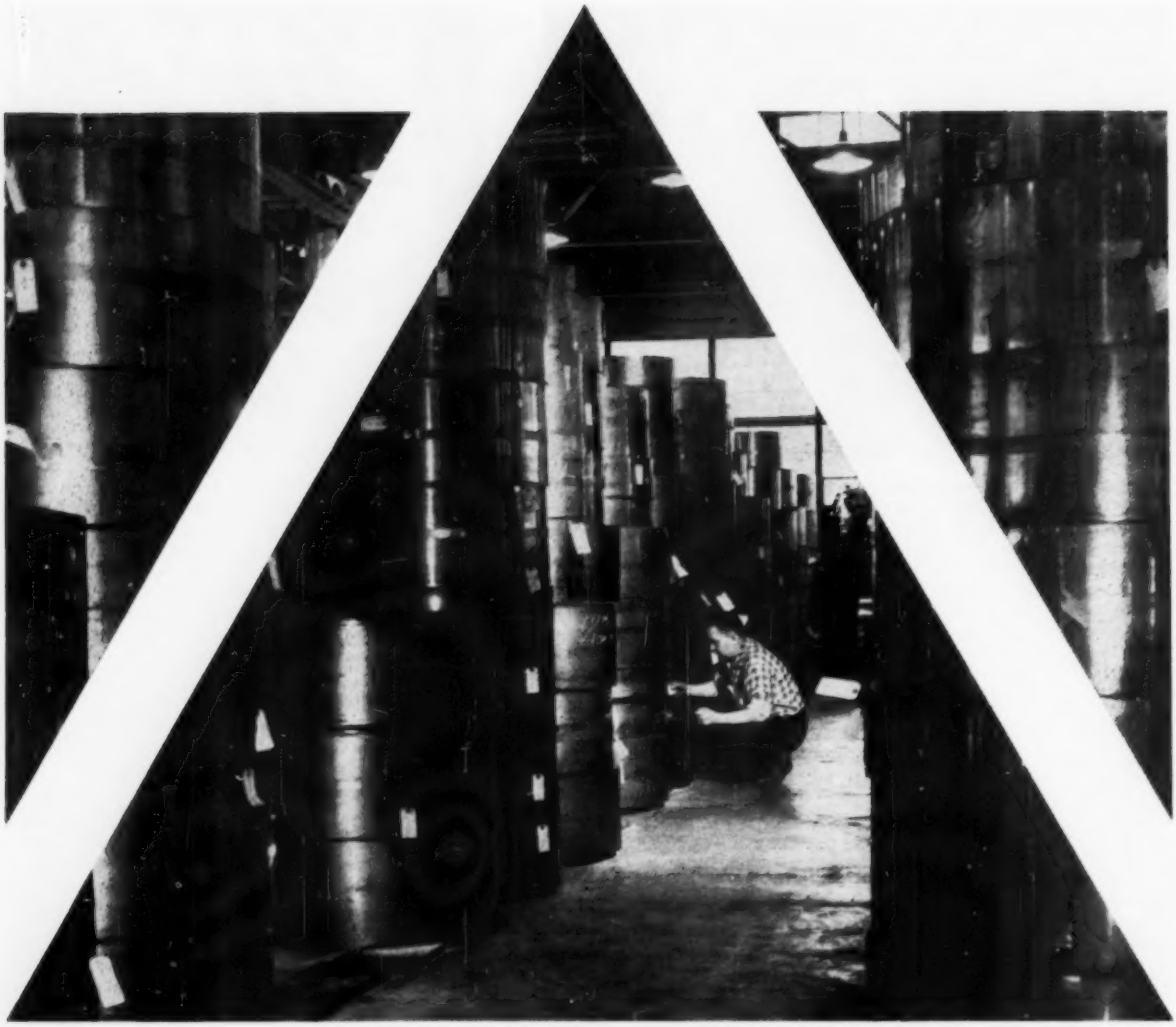
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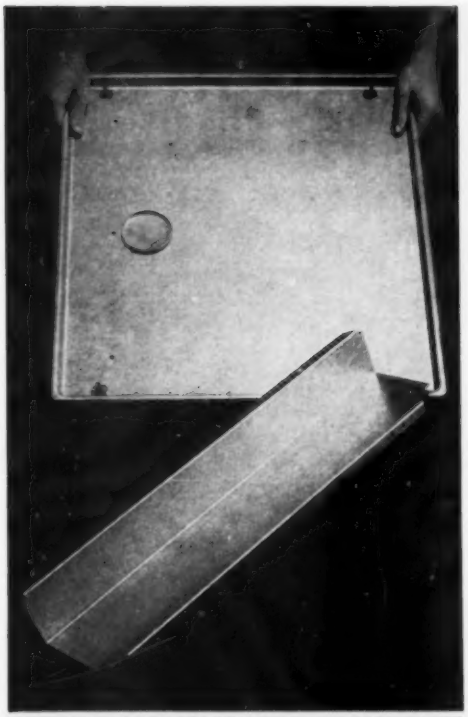


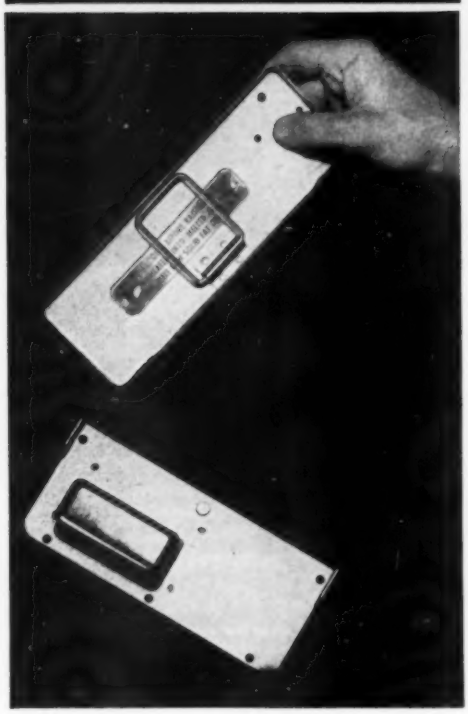
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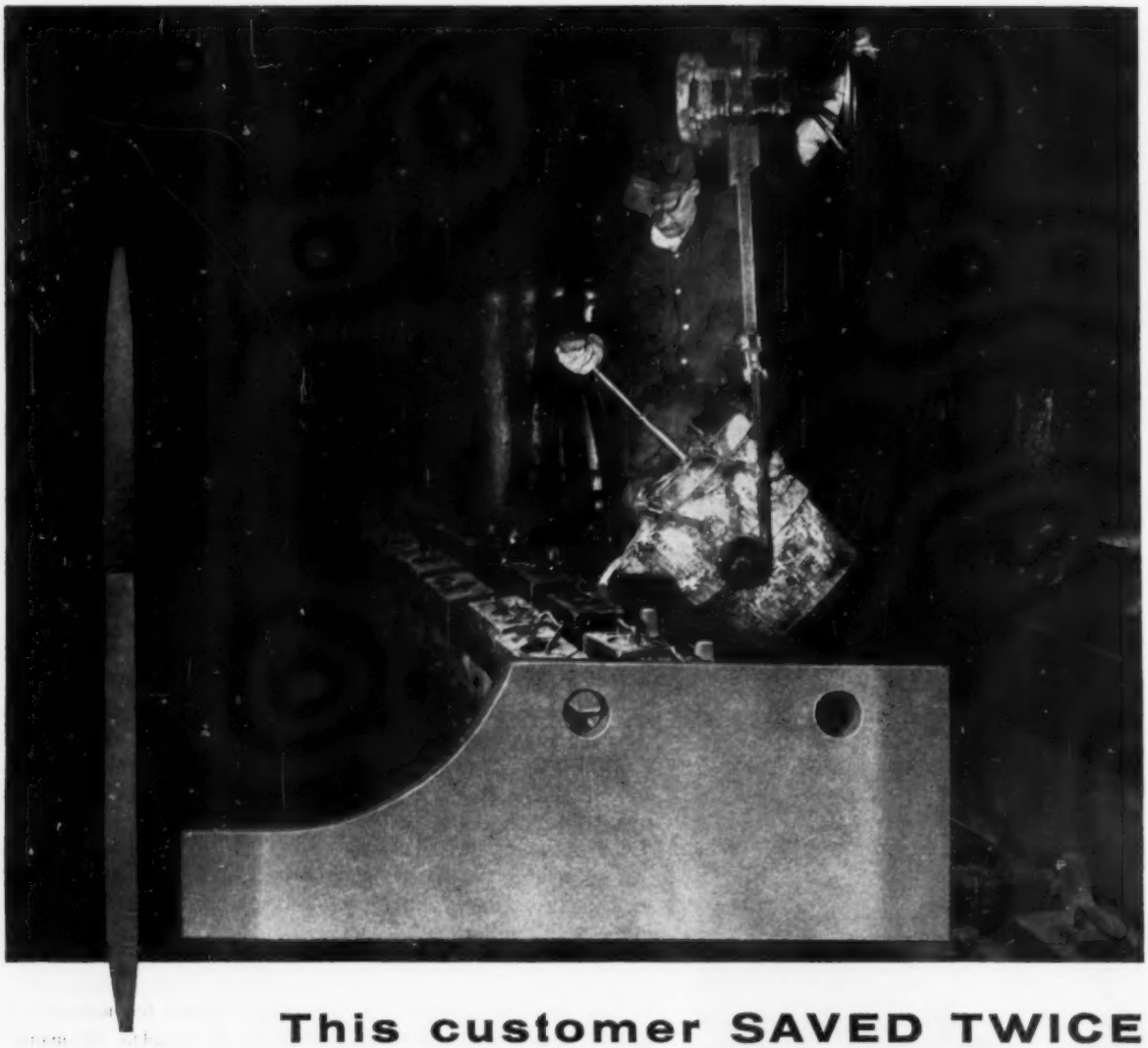
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This customer SAVED TWICE with Ampco Shell Moldings



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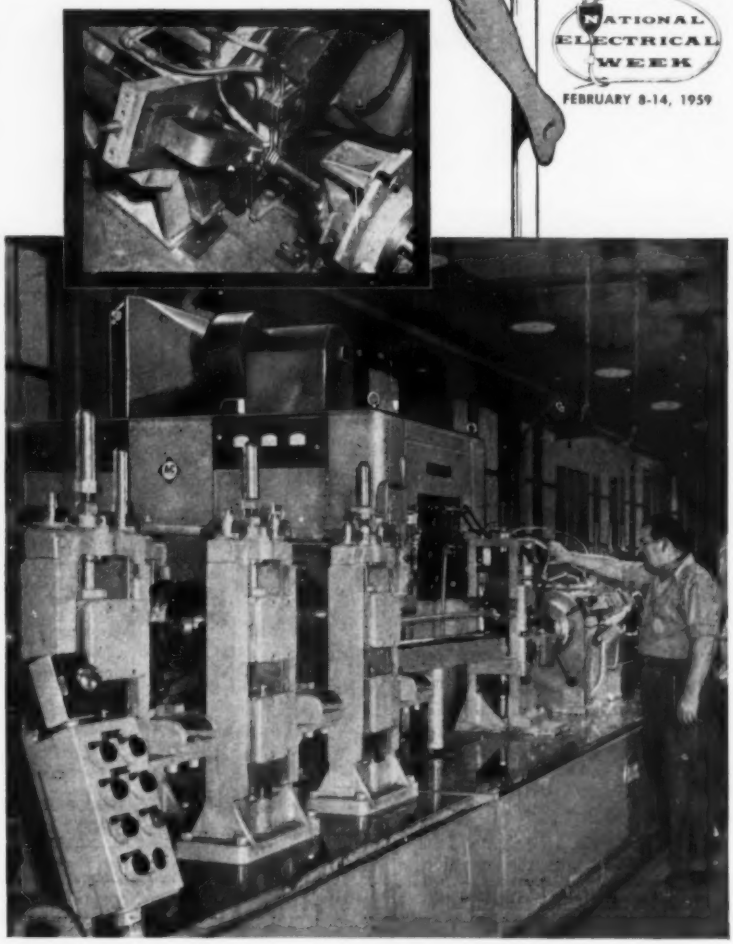


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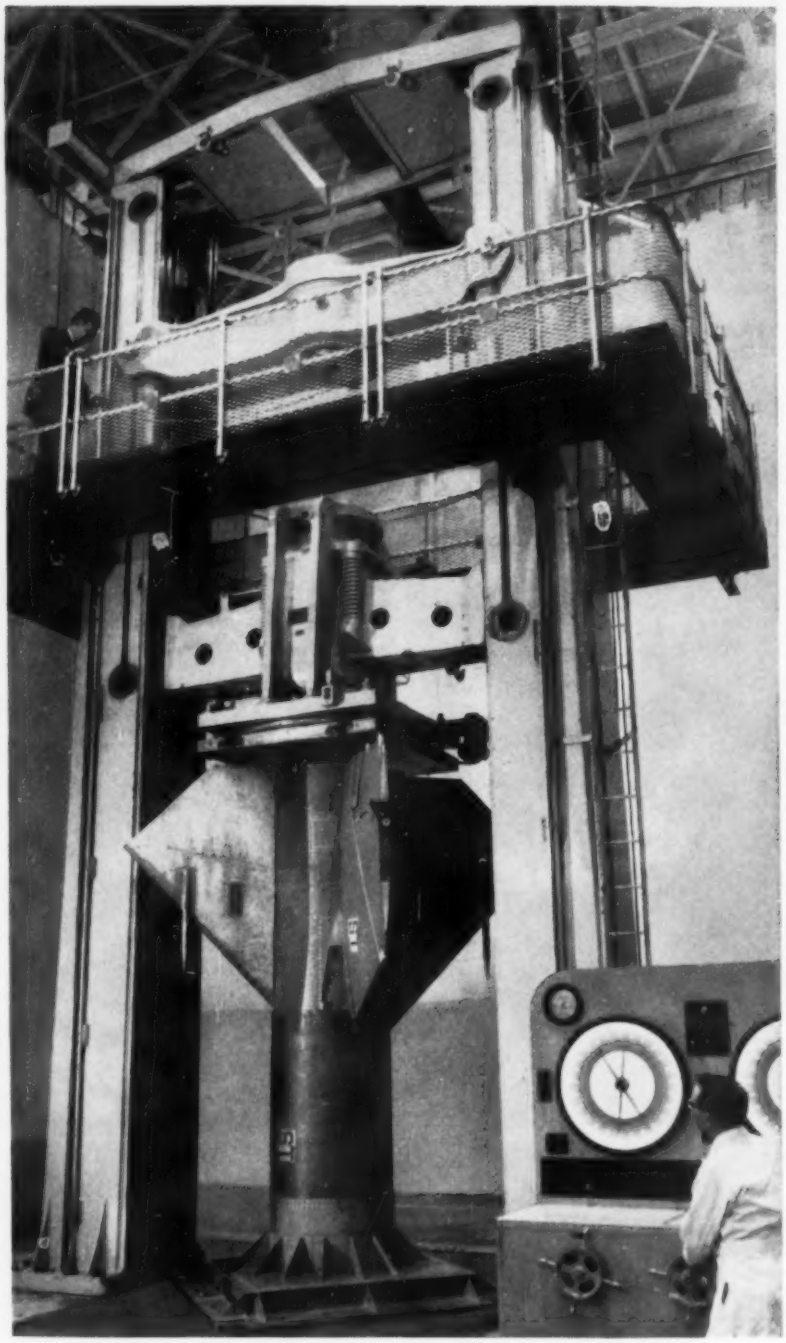
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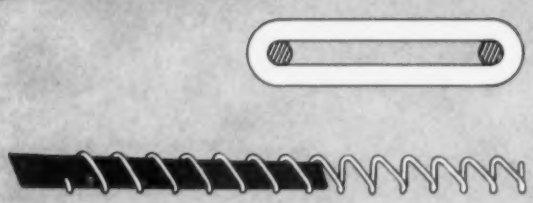
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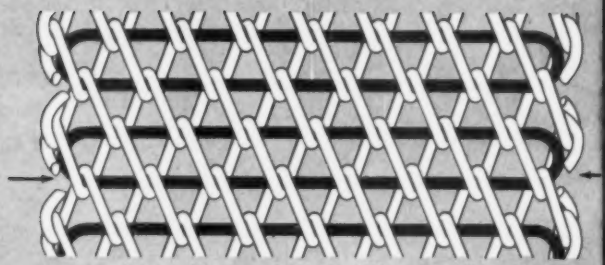
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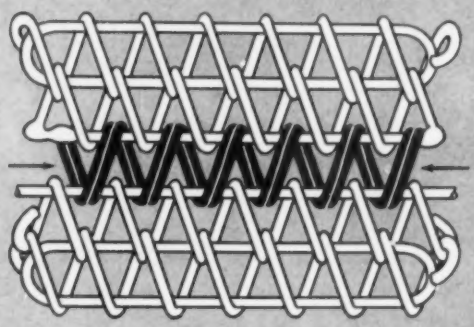
WISSCO'S EXCLUSIVE THIN FLAT SPIRAL is *formed* thin and stretch-resistant . . . provides a smooth supporting surface for heavy loads or tall, slender objects . . . distributes the wear over a large area.



WISSCO'S DUAL CONTINUOUS REINFORCING ROD — Two adjacent rods are joined to form a flattened oval. The extremities of this oval are located inside the knuckled edges of the belt to give full reinforcement and prevent narrowing of the belt.



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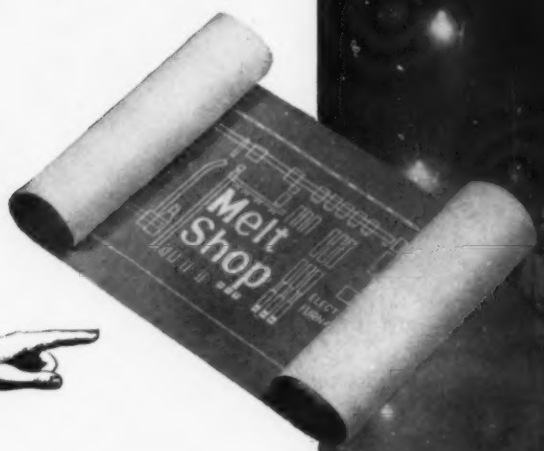
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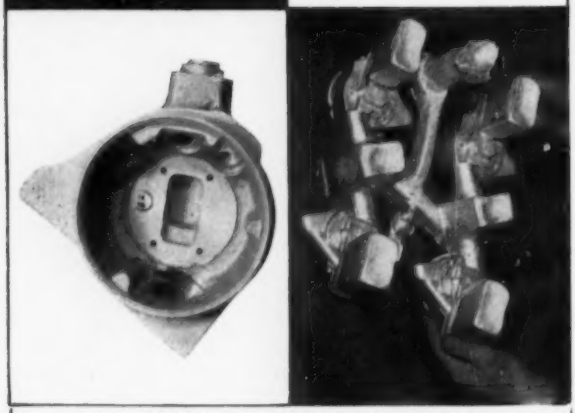
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has urgent need for qualified technical personnel. As contract operator for the Atomic Energy Commission, the National Lead Company of Ohio operates the Feed Materials Production Center near Cincinnati, Ohio. Technical activities at the project involve plant assistance, process development, and process improvement aimed at more economical production of uranium fuel elements for use in nuclear reactors.

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B.S. degree in Metallurgical Engineering with a minimum of 5 years' experience in the field of physical metallurgy. Experience in metallography and heat treatment desirable. Position involves supervising programs concerning the heat treating of uranium, metallography, and the evaluation of fabrication processes.

Please send resume of education, experience, and salary requirements to

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National Lead Company OF OHIO

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XXX

This is the thirtieth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Evaluating the Machinability of Alloy and Carbon Steels



To produce a useful part, most steel has to be shaped by one or more of the metal forming methods. One of these is metal cutting or machining, which changes the shape, size, or finish of a workpiece.

Alloy or carbon steels are often received from the mill in the raw form of bars, forgings, or castings. The steel is placed in a suitable machine, such as a lathe, multiple-spindle automatic bar machine, drill press, milling machine, or one of a number of other types. Metal is then removed from the steel stock until it has acquired the desired shape. This is accomplished by causing motion to take place in the sharp-edged cutting tool, or the piece of steel, while they are held in contact with each other. Cutting tools, such as drills, tool bits, milling cutters, and the like, are made from highly-alloyed steel (tool steel), cast alloys, sintered carbide, or even ceramic material.

During machining, the metal is removed in the form of chips which may be of any length, from the short, well-broken type, to the long, stringy and continuous variety—depending upon the nature of the steel, the shape or geometry of the cutting tool, the speed and feed at which the cutting is done, and the coolant or cutting fluid applied.

"Machinability" of steel refers primarily to the ease with which it can be reduced to its final shape. It is measured by the speed and feed at which it can be cut, the quality of the surface finish produced, the length of time the tools will last, and the kind of chip formed in cutting. In a "free-machining" grade of steel, for example, high speeds and feeds can be used, tools will stand up well, surface finish will be good, and chips well broken.

Machinability is evaluated in the shop by the number of pieces having a satisfactory finish, within the required dimensional tolerances, that can be produced in a shift, or a day, with adequate tool life.

It can be appreciated that the study of the cutting of metals involves a large number of variables. These may be grouped in the following way:

1. Steel Analysis (Process, composition, microstructure, and mechanical properties)
2. Machine Tool (Condition, tool accessories, range of cutting speeds and feeds with ample power, etc.)
3. Type of Machining Process (Turning, milling, forming, broaching, etc.)
4. Cutting Condition (Speeds, feeds, and depth of cut)
5. Cutting Tool (Composition, treatment, hardness, size, shape, grinding and surface finish)
6. Cutting Fluid (Characteristics, application, and volume)

From this number of complex factors, laboratory tests and investigations have developed experimental data by using single variables, such as steel analysis, tool analysis, tool shapes, and cutting fluids. This information has proved to be a useful guide when combined with industrial experience; for no test method by itself has yet been developed that will include all the characteristics of a specific single or multiple-machining operation.

Bethlehem metallurgical engineers have had long and varied experience and knowledge on the machinability of alloy and carbon steels. They will gladly give you any help you may require in connection with machining problems.

In addition to manufacturing all AISI standard alloy steels, Bethlehem produces other than standard analysis steels, and the full range of carbon grades. Call your nearest Bethlehem sales office for information.

If you would like reprints of this series of advertisements, please write to us, addressing your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa. The subjects in this series are now available in a handy 44-page booklet, and we shall be glad to send you a free copy.

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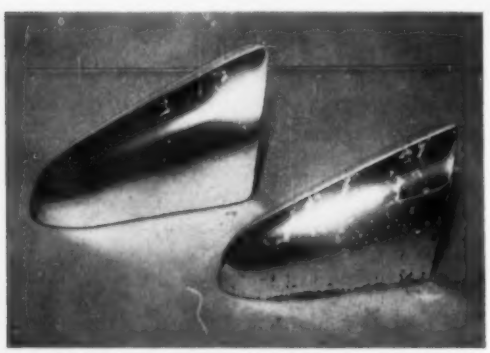
BETHLEHEM STEEL

How to match chromium plate to design requirements

No longer is all chromium plate alike physically despite the fact that it remains the same *chemically*.

FOR MORE CORROSION RESISTANT BRIGHTWORK

The newest type of bright chromium plate offers much greater corrosion resistance than previously obtainable. It is free from the microscopic cracks inherent in ordinary chromium deposits and thereby prevents corrosives from contacting the underlying metal. For this reason, Unichrome *Bright* Crack-Free Chromium makes a major improvement in the corrosion resistance of decorative brightwork. It assures more uniform plate distribution and ample thicknesses in recesses. And with freedom from the cracks characteristic of ordinary chromium, Bright Crack-Free Chromium actually *reinforces* the resistance of the copper and nickel undercoats normally used.

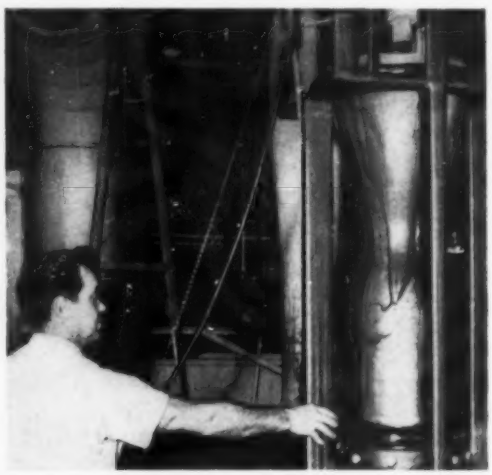


Bright Crack-Free Chromium promises to put an end to pitted and rusted auto brightwork. It plates without cracking, and eliminates pores by producing thicker bright deposits free from cracks. (Compared with ordinary chromium after 72-hour acetic acid salt spray test.)

TO OVERCOME CORROSION, WEAR, HEAT

Another new type of plate, Unichrome *Industrial* Crack-Free Chromium, delivers greatly improved corrosion, wear, and heat resistance for industrial or engineering-type applications. A ductile matte deposit free from corrosion-admitting cracks, it has excellent resistance to impact, abrasion, and thermal shock. Hardness ranges from 500 to 700 Knoop.

These properties of Unichrome Industrial Crack-Free Chromium are used to protect rocket engine assemblies subjected to hot, erosive, corrosive combustion gases. They also solve corrosion and wear problems on parts such as hydraulic rams, power steering shafts, high temperature molds, and washing machine shafts.



Resistance to thermal shock and superior corrosion resistance suit Unichrome Industrial Crack-Free Chromium for such uses as plating of rocket engine combustion chambers.

FOR OTHER APPLICATIONS

A third process, Unichrome SRHS® Chromium, has proved uniquely successful in applications where freedom from cracks is not required. It plates up to 80% faster than the ordinary chromium process, deposits chromium with less dulling and burning due to its unusually wide bright plate range. Its unique production advantages lead to an engineering benefit: more uniform control of plating quality.

NOTE: SRHS Chromium excels for plating stainless steel, enabling designers to "color-match" all brightwork on a product.

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All the men in the photograph are MEI graduates . . . and, from the start, they had one important thing in common. They all work with metals. They can all personally benefit from a better, more current, knowledge of metals.

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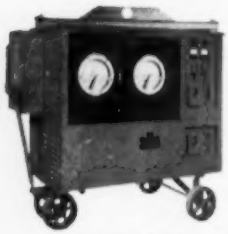


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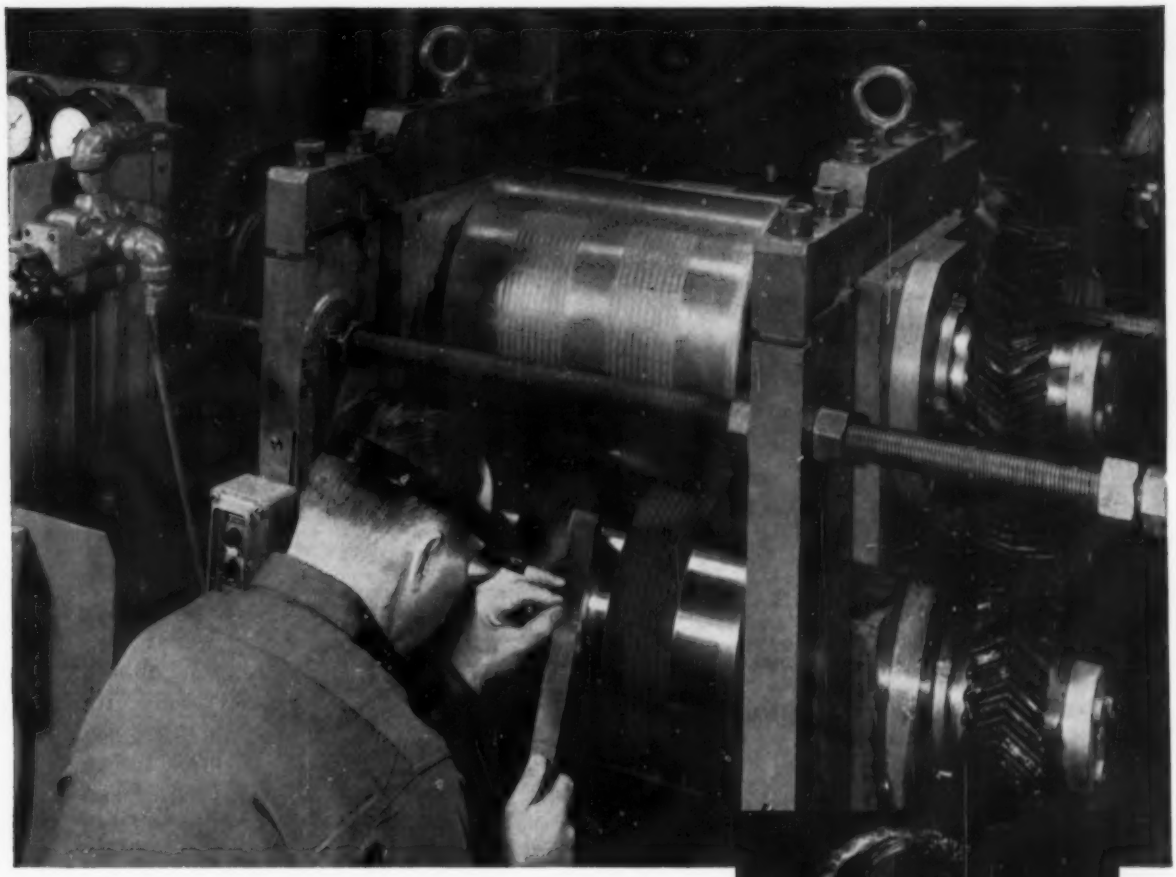
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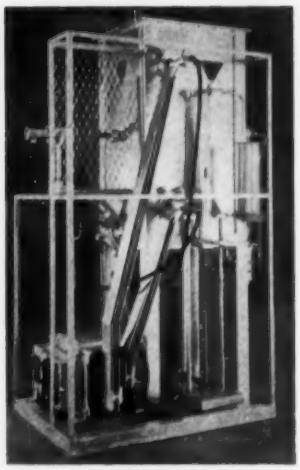
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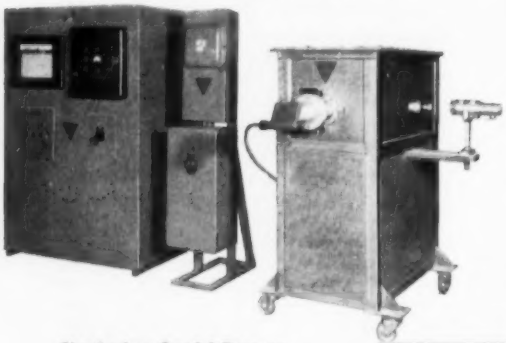
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Description	Model	Cu.Ft.	Temp. Range		Outside Dim.			Inside Dim.		
			Rm. 70°	Rm. 110°	L	W	H	L	W	H
Sub-Zero	SZH153	1.5	–95° F.	–85° F.	42"	28"	42¾"	23"	9"	12½"
Sub-Zero	SZH653	6.5	–85° F.	–75° F.	60"	28"	42¾"	47"	15"	16"
Sub-Zero	SZHC657	6.5	–140° F.	–125° F.	60"	28"	42¾"	47"	15"	16"
Rivet Cooler	RSZ503	5.0	–30° F.	–20° F.	42"	28"	41"	30"	16"	18"

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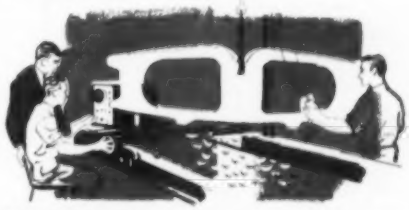
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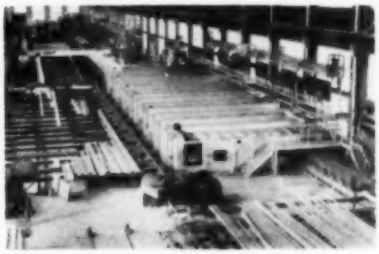
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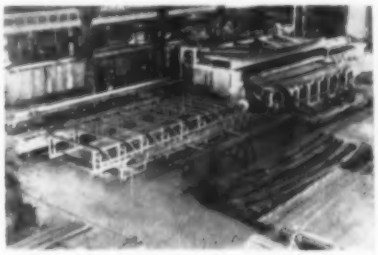
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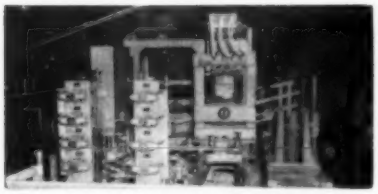
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